

MATHEMATICAL CONCEPTS USED BY PLUMBER

A THESIS

BY

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DEGREE OF MATHEMATICS EDUCATION**

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LETTER OF CERTIFICATION

This is to certify that Sujan Shrestha a student of academic year 2072/73 with campus Roll No. 140 Exam Roll No. 7228406, thesis number 1499 and T.U. Regd. No.9-2-29-1145-2011 has completed this thesis under supervision of Dr. Bed Prasad Dhakal during the period prescribed by the rule and regulation of Tribhuvan University, Nepal. This thesis entitled "**Mathematical Concepts used by Plumber**" has been prepared based on results of his investigation. I, here by recommended and forward that his thesis be submitted for evaluation as the partial requirements to the degree of Master of Mathematics Education.

.....

Head

Prof. Dr. Bed Raj Acharya



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LETTER OF APPROVAL

This thesis entitled "**Mathematical Concepts used by Plumber**" submitted by Mr. Sujan Shrestha in partial fulfillment of the requirement for the Master's Degree in Education has been approved.

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RECOMMENDATION FOR ACCEPTANCE

This is to certify that Mr. Sujan Shrestha has completed his M. Ed. thesis entitled "**Mathematical Concepts used by Plumber**" under my supervision during the period prescribed the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal. I recommend and forward his thesis to the Department of Mathematics Education to organize final viva-voice.

.....

Dr. Bed Prasad Dhakal

(Supervisor)

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Defense Date:

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DEDICATION

Honestly dedicated

To

My parents

Rajan Shrestha and Maya Devi Shrestha

DECLARATION

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

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Sujan Shrestha

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August, 2021

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Sujan Shrestha

Abstract

This is an ethnographic case study related to mathematical concepts used by plumbers. The objectives of the research were to identify the mathematical ideas/skills used by plumbers, to identify how do they acquire those mathematical ideas and to suggest the pedagogical implication of plumbing in mathematics curriculum. The respondents of the research were two plumbers of Lalitpur District who were selected purposefully. Data collection tools were Non-Participant Observation and Interview. Collected data were analyzed on the basis of general inductive approach and acquisition of mathematical knowledge with reference to social constructivism.

The result showed that many conventional mathematical concepts are embedded in the work of the plumbers during the work. Plumbers need many mathematical ideas like fundamental operation of mathematics, measurement, plane, circle, cylinder, angle, parallel, perpendicular, straight line, etc. Plumbers acquired that mathematical knowledge through experience and practices, practical activities and circumstances, social interaction, observing the adult work. It is concluded that plumbers used the similar mathematical contents of formal mathematics in their own way. So I recommended that ethno-mathematical concepts used by ethnographic group should be incorporated in school mathematics curriculum, which helps effective learning in school mathematics.

Table of Contents

LETTER OF CERTIFICATION	i
LETTER OF APPROVAL	ii
RECOMMENDATION FOR ACCEPTANCCE	iii
DEDICATION	v
DECLARATION	vi
Acknowledgement	vii
Abstract	viii
Table of Contents	ix
Chapter I.....	1
INTRODUCTION	1
Background of the Study	1
Introduction to Plumber and Plumbing.....	1
Statement of the Problem.....	2
Objectives of the Study.....	3
Justificance of the Study	3
Delimitation of the Study.....	3
Operational Definition of Related Term	3
Chapter II	5
REVIEW OF RELATED LETERATURE.....	5
Empirical Literature Review.....	5
Theoretical Literature Review	8

Constructivism	8
Social Constructivism	9
Conceptual Framework of the Study	11
Chapter III.....	13
METHODOLOGY AND PROCEDURE	13
Design of the Study.....	13
Selection of Respondents.....	14
Background of the Respondent.....	14
Tools for Research	15
Interview	15
Non-Participation Observation	16
Data Collection Procedure	17
Data Analysis Procedure.....	17
Chapter IV.....	18
Analysis and Interpretation	18
Tools used by Plumber.....	18
Types of Pipe Fittings:	22
Mathematical Concepts used by Plumber.....	25
Pedagogical Implication of Plumbing in Mathematics Curriculum	30
Chapter V	32
Findings, Conclusion and Suggestions	32

Findings of the Study	32
Conclusion	33
Suggestions	34
Educational Implementation	34
REFERENCES	35
Appendix-I: Interview Guidelines for Researcher	37
Appendix-II: Non-Participant Observation Guidelines for Observer	38
Appendix-III: Photographs	39

Chapter I

INTRODUCTION

Background of the Study

Mathematics is study of numbers, shapes, quantities, pattern, arrangement and many more concepts. Knowingly or unknowingly we use mathematics in our everyday work. Education is defined as art of imparting knowledge, skills and fact that we need in our daily life. In this sense we can say education is modification of behaviour. And mathematics education is combination of two words mathematics and education. So mathematics education is art of imparting knowledge, skills and fact that we need in our daily life which are related to mathematics. As we know mathematics is very essential subject for our daily life, it is included in national curriculum as compulsory subject from class one to ten. But there is gap between the mathematics practiced in our daily life and the mathematics that are taught in school. The mathematics which are taught in school and that which are practiced in everyday life is treated as two separate subjects which makes math difficult as well as useless and meaningless. It is believed that mathematics is most useful subject but student cannot use mathematics as they learn in school in their day to day life. It would be very meaningful if we could able to teach mathematics by giving examples from our surrounding.

Introduction to Plumber and Plumbing

A plumber is person who furnishes or fits and repairs pipes. Plumber also specialize in installing and maintaining system used for drinking water, sewage and drainage in plumbing systems. The term dates back from ancient times and is related to Latin word "Plumbum". In the context of Nepal plumber is known is unskilled person but it needs years of training or experience to be a skilled plumber. Nowadays plumber is also one of the most popular job in city of Nepal. A plumber's job role consists of installation, repair, maintenance and servicing of plumbing fittings and fixtures. As we may be aware, water is supplied to a

house or a building from storage tank through pipes. Similarly, the waste water from kitchen and washroom is drained with the help of pipes (Cited <https://www.wikipedia.org>).

The skills and art that is needed to transport water from the source to the users then to the treatment plants, and finally supplying the treated water to the users through the distribution system is known as plumbing. It is system of pipes and fittings that carry water. There are many plumbers all over Nepal. Plumbers needs different mathematical knowledge. They use mathematics in different way.

Statement of the Problem

Participation in education is an important dimension to access the development of a society. Education develops the human resources which is interpreted as a process of increasing the knowledge, skills and capabilities of all people in the country. But in the context of Nepal, all people do not get the chances of education due to social, economical and cultural barriers. Some of them acquire knowledge from own construction, they built mental scheme by ethno-mathematical process. Ethno-mathematical process is a process of achieving knowledge through society and culture.

There is no doubt that knowledge gained from experiences is never forgettable. So the teaching strategies should be based on real life experiences. We can see pipe fittings in everyone's house every day. It is believed that mathematics is itself is difficult subject. Inside mathematics geometry is tough one. Example is the best tool to explain. If we would be able to give example of the phenomenon of our surrounding it will be easier to understand and be set in mind. If we can explore the mathematical concepts in the pipe fittings we can make examples from it so that the children would enjoy the mathematics and it would be long life. It would be beneficial if we could give example of our daily work in mathematics while teaching mathematics. So the researcher took a research project entitled "Mathematical Concepts Used by Plumber" with following objectives:

Objectives of the Study

The objectives of the study are as follows:

- i. To identify major mathematical knowledge used by plumber.
- ii. To analyze the process of acquiring the mathematical knowledge by plumber.
- iii. To suggest the pedagogical implication of plumbing in mathematics curriculum.

Justificance of the Study

There are various ethnic groups in Nepal. Every ethnic group has its own occupation. And in every occupation mathematics is used uniquely. In such a way everyone need knowledge of mathematical concepts. Among them plumber is also an occupation whose work is to fix, manage or fits the water pipe and drainage. Mainly the significance of the study will be:

- Promoting ethno-mathematical knowledge and recommend such activities with formal and non-formal education.
- Bridge the gap between mathematical knowledge learned in school and practiced at home.
- Helps to teach mathematics meaningfully.

Delimitation of the Study

The study is limited only in the study of mathematical knowledge used by a plumber. the study will have the followings limitations.

- The study was based on plumbing of house.
- The study was conducted in Lalitpur district.

Operational Definition of Related Term

Plumber:

The one whose job is to install, repair, maintenance and servicing of fitting and fixtures. The work of plumber is known as plumbing. It includes the skill and art that is

needed to transport water from the source to the users through distribution system. It is a system of pipes and fittings that carry water.

Basic Mathematical Concepts:

The sense whether to add, subtract, multiply or divide know as basic mathematical concepts. While solving our real life problem it plays vital role.

Mathematical Concepts:

Mathematical concepts refer the broad area. In the research mathematical concepts refer the concepts of use of geometry, arithmetic, concept of length, weight etc.

Fundamental Operation of Arithmetic:

Four basic operation of math namely addition, subtraction, multiplication and division are known as fundamental operation of mathematics.

Chapter II

REVIEW OF RELATED LITERATURE

There are many literatures on the other field of study but very few attempts have been made to study of used of mathematics.

Empirical Literature Review

Khanal (2008) studied on the research “Ethnographic Study on the Mathematical Concepts and Process used by Potter”. The study was conducted on an ethnographic basic. She found that while making mud pot such as flower-pot, water vessels, HANDA, HANDI, KHUTRUKI, CHULO, PALA, AARI etc mathematical concepts: Centre, Straight line, Plane, Area, Circle, Sphere, Rectangle, Cylinder, Trapezoid, Three Dimensional geometric figures are applied knowingly and unknowingly. To acquire above mentioned mathematical entities they mostly used Potters Tools, Base Cutting Tread, Knife, SIKKHA, Potter’s Wheel etc. it is concluded that the gaining of knowledge is a process of observing, reflection of thinking, performing, practicing, and creation. To fulfill each and every mathematical needs potter used applied mathematical concepts knowingly and unknowingly. From this ethnographic study it discovered that the potter used many mathematical concepts in their daily pottery works but they are unconscious about the meaning.

Subedi (2008) studied on mathematical concepts of Tharu children developed through toys and games. The research was conducted 6 moths long in Parsa District with the objectives to identify games and toys played by children of Tharu community and to find out the mathematical concepts developed by Tharu children through games and toys. The study was case study about games and toys played by Tharu children and method were participant and non-participant observation. Social constructivist theory was applied in the analysis of data and presentation of the study participant observation and interview were the tools for the study since the study was qualitative. To support the finding of the study constructivist theory

and Vygotsky's theory of social constructivism were used. The researcher found that Tharu children applied many mathematical concepts in their daily playing task but they knowingly or unknowingly, their mathematics has several unique characteristics and the conventional mathematics. It is mentioned that most of their work concerned about making and drawing square, triangle, rectangle, circle, sphere and many more geometrical shapes. To make the listed materials and shapes they use mathematical concepts as plane, perpendicular, straight line, parallel lines and center.

Adhikari (2006) did his dissertation on the topic "A Study on the Masons Developing Mathematical Concepts in Their Surrounding" with the objectives to identify the types of the mathematical concepts, do the masons need and to identify the process of acquisition of those mathematical concepts by masons. The researcher found that the mathematical concepts used by masons are the concept of plane, the concept of perpendicular, the concept of straight, the concept of parallel, the concept of area, the concept of triangle and congruence, the concept of center, to cover the above mentioned concepts they used Measuring Tape, Gauging, Trowel, Float, Plumb, Mason's Square, Club Hammer. They acquire those mathematical concepts, through experience and practice, observantly through their guardians, socially constructed by process of communication, apprenticeship, physical activity, reflection and interaction, art and creativity. It is concluded that the gaining of knowledge is a process of reflection of thinking and creation. To fulfill each and every needs of human life, masons used applied mathematical concepts knowingly or unknowingly. It is mentioned that mostly they work for making door, windows, ventilation, square and rectangular frame of building. To make above lists of materials, they applied mathematical concepts: the concept of plane, perpendicular, straight line, area, parallel, congruence, triangle and center knowingly or knowingly.

Kadayat, (2009) finds in his thesis entitled “A Study on Mathematical Concept used by Weaving Woolen Carpet” that the mathematical concepts used by carpet weavers are: the concept of perpendicular, the concept of parallel, the concept of straight line, the concept of plane, the concept of area, the concept of curve and curve tracing, the concept of graph, the concept of circle, the concept of polygon. To carry out the above mentioned concepts they used measuring tape, TAAN, weaving rod (GHIMPSE), KHOPIN wood, hammer, knife, PANJA (comb beater), scissors, graph, ROKAT, cross HULU, NAY wood, HULU, THAKAT (Loon). They acquire the above mentioned mathematical concept through experience and practice, observantly through the guardians and peer group, socially constructed by process of communication, apprenticeship, physical activity, reflection and interaction and art and creativity. The study was case study about two carpet weavers and the method was observation. The study was conducted for six months.

Subedi, (2009) finds in his research entitled “Mathematics in Wicker Worker” the mathematical concepts used by wicker worker are the geometrical shapes such as cylinder, straight line, sphere, circle, triangle, quadrilateral, cone, frustrum, similarity, congruency, symmetry, perpendicularity, parallel lines, angle, area and volume. They acquire the needed mathematical concepts through insight and drill, through observation of series work, interaction, working, reflection. The study was conducted in Lekhphat V.D.C. ward 1 and 3 using the ethnographic case study under the qualitative research design.

From the above empirical literature review, it is concluded that no doubt that mathematics has huge uses in our everyday life. The research has done on some of the field but no research has been done on mathematical concepts and process used by plumber. So the review of the above literature helped to know that no research has been done on concerning mathematical concepts used by plumber.

Theoretical Literature Review

In this chapter, the researcher introduces the theoretical discussion, which is relevant for the data collection and interpreting the findings of the study. There are various theories related to children's learning and development. Gestalt theory, social construction, cognitive construction, radical constructivism, Ausubel's theory and so on. For the study, the Vygotskian theory of social construction and constructivist theory were used for the data collection and interpretation of findings of the study. According to Hover (1996), constructivism means a kind of consideration about themes and build up a strong mental plan. So different individual has their own construction about existing phenomena. Learning mathematics requires active construction not passive reception and to know mathematics requires constructive work with mathematical objects in mathematical community. According to Cook (1992), constructivism is a philosophy of learning founded on the premise that by reflecting on your experiences. We construct our own understanding of the world. We generate our own rules and mental models which we use to make sense of our experiences learning therefore is simply the process of adjusting our mental model to accommodate new experiences, so the researcher used the social constructivism theory to interpret findings of the study.

Constructivism

Simply, constructivism means a kind of consideration about themes and build up a strong mental plan. So different individual has their own construction about existing phenomena. Learning mathematics requires construction not passive reception and to know mathematics requires constructive work with mathematical objects in a mathematical community. Constructivism is a philosophy of learning founded on the premise that by reflecting on our experience, we construct our own understanding of the world, we like in each of us, generate our own rules and mental models which we use to make sense of our

experiences. Learning therefore, is simply the process of adjusting our mental models to accommodate new experience.

A major theme in the theoretical framework of Bruner is that learners construct new ideas or concepts based upon their current prior knowledge. According to Fosnot (1989) the learner selects and transform information, construct hypothesis and makes decisions relying and cognitive structure to do. Cognitive structure provides meaning and organization to experience and allows the individual to go beyond the information given. It is obvious people do make their own meaning from their own beliefs, construct new ideas from what they observe, listen and perceive. They do not always use the taught method but use their own strategies to solve their problems on their own. Constructivist assumes that learners construct their own knowledge on the basis of interaction with their environment. In this context Piaget writes, “knowledge is not passively received rather knowledge is actively created by students. Mathematical ideas are made by learners not found like a pebble or accepted from other like a gift.

Social Constructivism

Vygotsky was famous scholar who emphasized the social constructivism. Social constructivism is a theory among several theories. The researcher used Vygotsky’s theory for this study that every knowledge is socially constructed. Children learn when they get contact with outer environment either verbally or observantly. Vygotskian theory is one of them that regards social interaction between peers and adults as important aspect in creating meaning making sense and conveying culture within the shared context. The social constructivism is the trend within the modern field of sociology of the knowledge. Sociology of the knowledge is an epistemological discussion of how is created and acquired. Social constructivism focuses on actual production of scientific knowledge. Therefore, it is not merely a study of how social factor and practical experiences influence scientific facts. Vygotsky (1987),

stresses that a child learn something first on the social level, then latter on at the individual level. It means children develop their skills through playing or increasing with peers and others adults. This means that social level takes first for initiation of the learning. The individual child then internalizes the skills. In the word of Vygotsky through such inter psychological process at the individual level. Therefore, internalization is a process by which the inter psychology becomes inter psychological is not a simple transfer from external activity to performed cognitive structures.

The learning is thus facilitated through speech, social interaction and co-operative activities. According to Schitizi (2002), Vygotsky's theoretical discussion reveals the psychological perspectives and describes about the insider of the individual. In other words, it is more focused on the individual beahviours relation to society or groups. So Vygotsky's theory of ZPD was helpful for use to build theoretical framework to understand the bahivour of the people as outside of the classroom. I have drawn the idea from ZPD that human behaviour is determined in the form of language, culture situation, communication, and social factor have influence in human behaviour. Knowledge is being constructed in social situation of negotiations, rather than being the reflection of the objective reality, which is termed as social constructivism. Social construction believes in multiple construction of world. In social constructivist theory, each human being makes sense of the world in a unique way (Combs & Neely, 1992). Vygotsky argues that the children development cannot be understood by studying the individual that is needs to examine the external world. According to social constructivist Vygotsky knowledge is constructed in two ways in the social context. Firstly, social interactions influence on the nature of knowledge that is constructed and processes of individual use to construct that knowledge. Thus the constructions are socially centered and in value, process of understanding, constructing meaning and making sense (Bruner & Haste, 1987). The children's construction of knowledge is not from individual but also from the

content, the context and the interaction with more others. There is the knowledge constructed by child needs some mediator such as parents, teacher and adults or peers to uplift his knowledge from the knowledge s/he has.

Rooth (2000) states the knowledge of children is expressed in children's egocentric language as cognitive and which is internalized by the growing of the age. The language is originally and primarily social. About the children thinking process, Vygotsky feels that child think syncretically about unfamiliar situations or objects. Vygotsky emphasized on interaction. For him mind is as active, organizing, principle, collaborating with the environment in transforming throughout towards as increasingly delicate adaption of thought to things and things to thought.

Conceptual Framework of the Study

From the above discussed point of views in related literature, mathematical concepts used by plumbers may be in different form. Such as numerals, geometrical form etc. The concepts can be found on the process of working, on tools using by them and on the pipe fittings. The following conceptual framework was constructed with the help of reviewed empirical and theoretical literature.

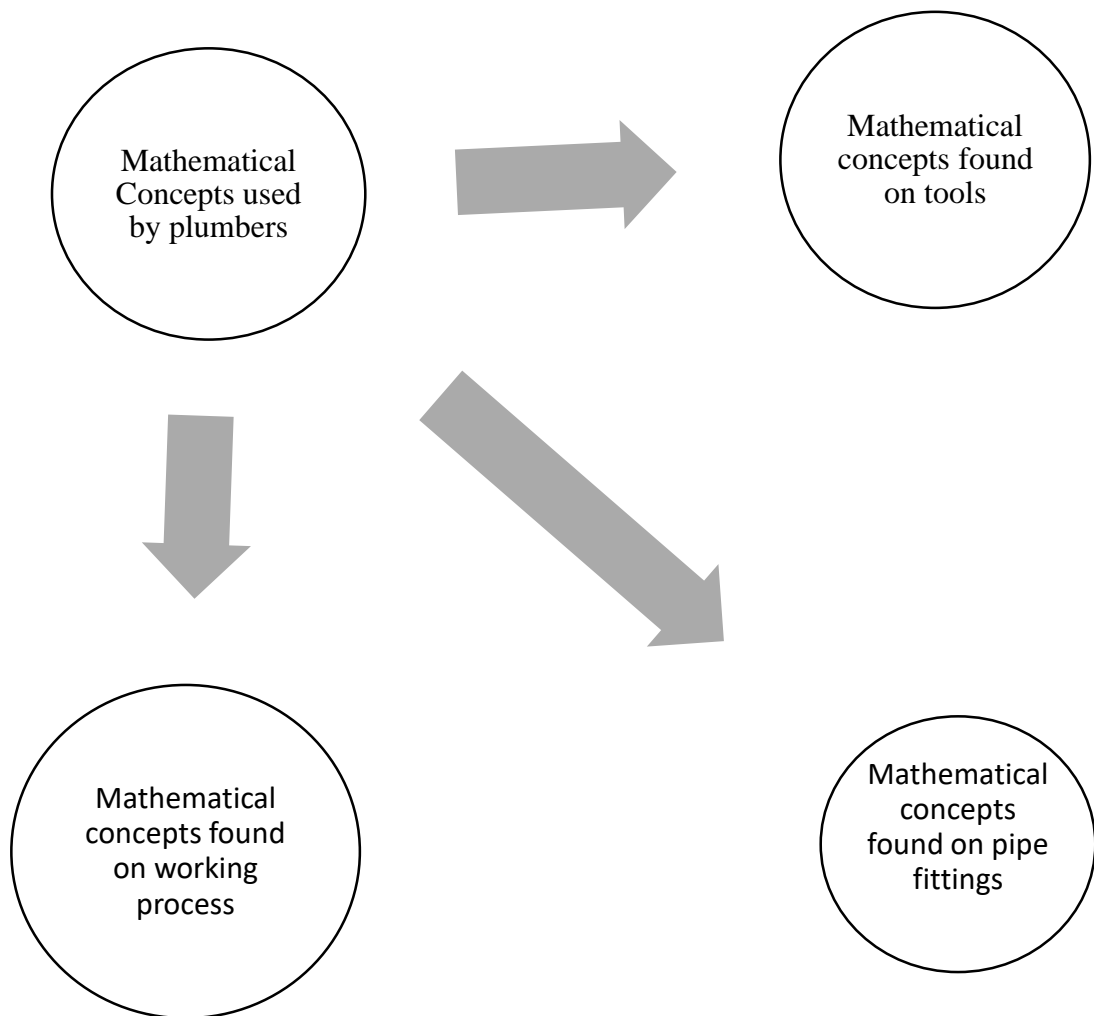


Figure no. 1

Chapter III

METHODOLOGY AND PROCEDURE

To make a systematic study of the above mentioned and to attain the objectives of the present study certain research procedures should be followed. The study is exploratory in nature. It has followed the qualitative research. Qualitative research is a form of inquiry that explores phenomena in their natural settings and uses multi-methods to interpret, understanding, explain and bring meaning to general audience. Qualitative research are any types of research that produces finding not arrived at by statistical producers or other means of quantification. It can refer to research about persons lives, lived experience, behaviours, emotions and feelings as well as about organizational functioning, social movements, cultural phenomena and interaction between notions (Creswell, 2012). Basically, there are three major components of qualitative research they are data, procedures and writing of memos. Since the objective of the study was to explore how mathematical thinking occur in plumbing, the researcher used non-participant observation and interview as a tools of the study. The conducted study was exploratory case study, which was a qualitative research in nature. This study was conducted to explain mathematical ideas used by used by plumber. The study was carried out on the basis of non-participation observation and interview.

Design of the Study

The study was based on the qualitative research design with ethnography approach. The qualitative design explores meaning and the way people understood things on their surroundings. Ethnography literally means a portrait of people. Ethnography is a written description of a particular culture, the customs, beliefs and behaviour based on information collected through field work (Moenen 1996). Ethnography is derived from anthropology. Ethnographic designs are qualitative research producers for describing, analyzing and interpreting a culture-sharing group's shared patterns of behaviour, beliefs and language that

develop over time. Ethnography is in-depth involvement in a culture to describe naturally occurring behavior. The approach to gathering data is to observe the culture or social group, interact with and interview members of the culture or the social group and analyze document and artifact (Khanal, 2004).

The conducted research was to explore the mathematical concepts used by the plumbers. Plumbers are also an ethnic group who shares a common cultural background. So, here the researcher has adopted ethnography approach as design of the study.

Selection of Respondents

The researcher purposefully selected two plumbers from Lalitpur district as respondents. One is working in B & B hospital in maintenance department, Gwarko. And another does the plumbing work of houses. Both the respondents are from middle class family and SLC graduate. Since the researcher had familiar connection with the respondent, it had been easier to get access with them.

Background of the Respondent

Permanent address of 'respondent A' is Jwalamukhi-5 Khari, Dhading. Temporarily he is staying at Imadole, Lalitpur with his family of four. He is age of 45 years old. After the completion of SLC he studied 2 years of plumbing course in Balaju Technical School, Balaju Kathmandu. He has a job at B & B hospital. He looks after the maintenance work of pipes. Besides that, he also undertakes the contract of new building for pipe fittings (plumbing work) and work on it. According to him he was poor in his study especially in English so couldn't study further. He has been working in the field since 25 years.

Permanent address of 'respondent B' is Jwalamukhi-6 Sunkhani, Dhading. Temporarily he is staying at Patan, Lalitpur with his family of three. He is age of 35 years old. He has studied formally up to SLC. His main job is to take contract on the under construction building for plumbing and also mends the water pipes and drainage in the old

building. Firstly, he started working with his uncle in this field and learned to work. Then after several years he started working independently. He has been working in this field since 10 years.

Tools for Research

Tools are very important for each study. There are many tools for qualitative research to get the information from the people about their experiences, ideas, beliefs. The researcher adopted non-participant observation and interview as different tools to answer the research questions. The researcher took interview with plumber and then visited the work place of plumber with them in order to observe how the mathematics used in plumbing.

Interview

The researcher made a small set of structured interview and used for respondents in the study and also used the unstructured interview to collect data. While he got new ideas and style he asked question as interview. Instead of writing the response, the subject or interviewee gives the needed information orally into face to face manner. Interview helped to get information which was not obtained from observation. The interview schedule was used to explain and investigations in what way plumber use mathematical concepts. The interview helped in clarifying questions if there remained any confusion. The researcher took the interview of two plumbers from Lalitpur District on two separate days.

The researcher at first went to B & B hospital, Lalitpur the workplace of respondent A and took interview. According to him he was poor in study especially in English so, he chose the technical field. On the researcher's question what is significance of Mathematics in plumbing? He replied it is quit harder in studying and working those who are weak in mathematics. So mathematics is more importance in plumbing such as to know the size of pipe, to convert one units to another, convert fraction to decimal and vice-versa, to calculate the total length of pipes required in a house for plumbing etc.

And then after few days the researcher went to the residential of respondent B Lalitpur in order to take the interview. He is 35 years old. He is also SLC graduate. At first he used to work with his uncle to learn the work and now he works independently. He has been working as plumber since 10 years. He takes contract of new building for plumbing and also mends the water pipes and fitting in old houses. According to him it is very important to choose appropriate size of pipe on the basis of size of water tank and number floor of the building otherwise it may cause the problem of low pressure or high pressure of water in the tap. The size of pipes taken in same building are also different.

Non-Participant Observation

The researcher used non-participant observation technique in collecting information. The researcher went along with the plumber, observed the way they work. The observed information was collected in daily work. In case study research observation is most frequent. The method of choice of behaviour modification studies that frequently use single subject research designs. Observation is most often used in small sample subject. Observation may be participant or non-participant. Non-Participant observation is that in which the observer is familiar and participate with the subject of study. This study was done in non-participation fashion where researcher observed himself as apprentice in the field.

The researcher went 2 days to the field work with the respondents on separate days and observed how they works and sometime asked the reason to do so. According to respondents before taking contract first he calculates the length of pipes required by multiplying the number of floor of the house with its height. The pipes are found in a pieces of fixed length. To calculate the number of pieces required he divides the total length of pipes required by the length of pieces of the pipe. And again to calculate the total cost of pipe he multiplies the rate and number of pipes. Also he estimates the required number pipe fittings such as elbow, union, valves etc. and their costs.

Data Collection Procedure

According to Best and Khan (2008), in a case study researcher use relevant tools and technique such as in-depth interview, participation observation and so on. In order to collect information from the respondent seeks meaning and understanding of phenomenon in natural setting. The researcher involved closely with the plumber and observed their activity. The researcher observed closely with the respondents in a natural setting as much as possible in order to collect essential data.

The researcher had gone 2 days for the observation with two plumbers. During this period the researcher got an opportunity to observe and find the mathematical concepts used in plumbing. It was found that working on irregular surface is very hard. First the plumbers have to make the ground plane if it is not. For the consumption of less pipe the plumber took the pipes parallel with reference to the fixed straight edge found nearer. The connectors of pipes are found in different angles such as 45° , 90° etc. by using them the plumber gave direction to pipe to the destination.

Data Analysis Procedure

The conducted study was qualitative, most of the data were collected through interview and non-participant observation. The collected information has categorized on the basis of different thematic view and the data were interpreted in a descriptive way. By the observation of plumbing works it became easy to find out the process of acquiring knowledge. The researcher analyzed the collected data on the basis of general inductive approach. It helped researcher by condense wide and varied raw text data into a brief summary format, establish clear link between the research objectives and the summary findings derived from raw data. And the acquisition of the mathematical knowledge was described with the reference to social constructivism.

Chapter IV

Analysis and Interpretation

This study is an ethnographic study related to the mathematical concepts used by plumber. I have tried to explore the mathematical concepts used in plumbing work. The objectives of the study were to identify the mathematical knowledge used by plumber & how do they acquire that mathematical knowledge and to suggest the implication in Mathematics curriculum. I purposefully selected two plumbers of Lalitpur district as respondents. I used non-participant observation and interview as tool of data collection.

Tools used by Plumber

While working plumbers are constantly faced with a number of plumbers navigating small spacing etc. to solve such a problem plumbers require the right tools and specific skill. A plumber requires several tools for the fitting work for plumbing, fixing a tap or to carryout repairs. These tools help the plumber in performing his/her work properly, and therefore it is important that the tools are used systematically and handled carefully to avoid any damage. The followings are the tools used by plumbers.

Measuring Tape: It is useful for measuring the length of an item. The measuring tape are found in various material such as steel, cloth, and PVC. The length available are one meter, two meters, three meters, five meters, ten meters etc. The plumbers use the measuring tape to measure the length of pipes before they cut.



Figure no. 2

Tube Cutter: A tube cutter is a tool used by a plumber to cut a metal's or plastic's pipe. It helps to cut the pipe parallel to its opposite face (circle). It has a sharp, round cutting wheel which is pressed with to and fro rotary motion for cutting a pipe. It has two jaws one is fixed and other is movable which is used to adjust the cutter according to the size of pipe. After the pipe is adjusted the pipe is rotated along with the sharp wheel of cutter to cut the pipe.



Figure no. 3

Hacksaw: A hacksaw is a tool used to cut metal. So the plumber used it to cut the pipes. Hacksaw doesn't make sure that the pipes cut are parallel to its opposite face. So the plumbers can cut the pipes in different angles according to their need. Also the plumbers have to make sure that the cut pipes are parallel to its opposite face if needed by their experiences if they need. The important parts of hacksaw are handle, frame and blade. Blade are straight whereas frame is straight with curve turning.



Figure no. 4

Hole Saw Kit: A hole saw kit is a tool used to cut perfectly round holes on metallic surface. The plumbers use the hole saw kit to make a circular hole on metallic of plastics water tank for outlet pipe. A hallow cylindrical plate with a blade at one open end and other closed end is placed in a drill like machine. Plumbers used the hole saw kit to make hole especially on metallic surface.



Figure no. 5

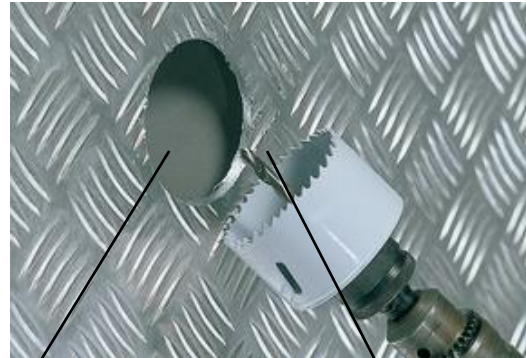


Figure no. 6

Cutting a circle

Center of circle

Pipe and Tube Bender: A pipe and tube bender is tool used to bend the metal pipes in different directions and angles. Generally, they are bended to form an elbow. Bending a pipe changes the direction of fluid in the pipe.



Figure no. 7

Pipe Wrenches: A pipe wrenches are used to tighten and loosen nuts and fitting on pipes. Two pipes wrenches are often used together one for holding a pipe in a place and other for rotating a nut or fitting. These tools hold a pipe and pipe fittings for screwing and unscrewing. This is a very common tool, especially for small diameter pipes up to 50mm.



Figure no. 8

Compass or Divider: Plumbers use compass and divider to inscribing the circle or arc. Plumbers also use it to measure distance.



Figure no. 9

Plumb Bob: A plumb bob or plummet is a weight usually with pointed tip on the bottom suspended from a string and used as a vertical reference line. It is essential to check vertical equivalent of a water level. It is also useful to ensure verticality and uniformity during construction of walls, columns and wooden frames like doors and windows. It also helps in

levelling the surface of floor. It consists of a holding pipe, thread and a plumb bob made of wood or metal. The plumb bob is connected to the holding pipe with the thread.

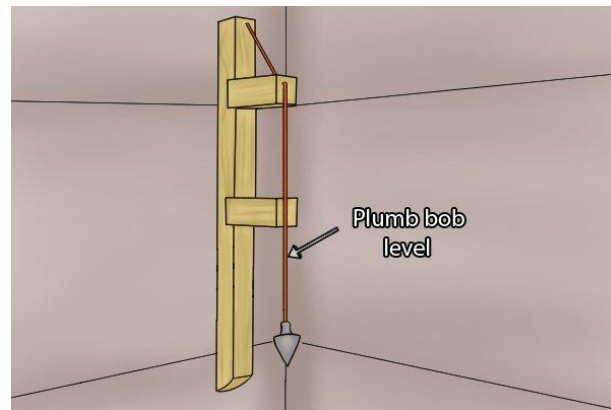


Figure no. 10

Types of Pipe Fittings:

Pipe fittings are an important component of the plumbing system. In plumbing, many types of pipes are joined with various types of fittings as per the requirement. Fittings are fixed in the plumbing system to join straight pipes. Fittings like elbow, tee, reducer etc. are fitted to change the direction of flow, distribute the water supply from the main pipe to other pipes of equal size or smaller size. The followings are types of pipe fittings.

Elbow: Elbows are used to join two pipes. There are two types of elbows. They are 45° and 90° . Elbows are used to change a direction of pipes. Plumbers use different types of elbow to reach a destination according to their need.

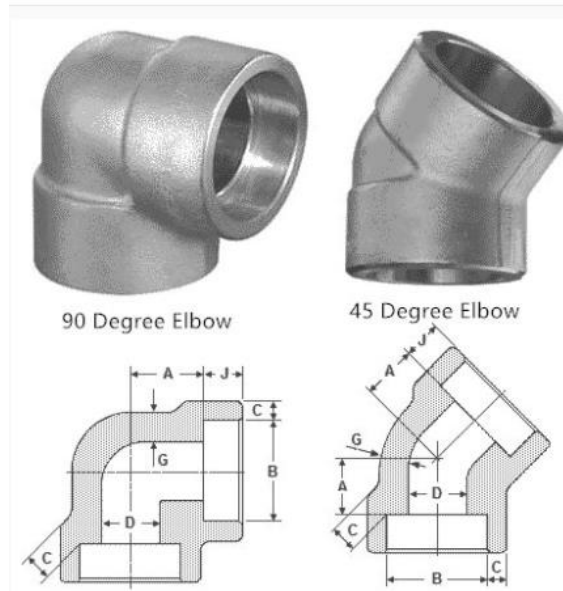


Figure no. 11

Couplings and Unions: Couplings and union are used to connect two pipes of same size in a straight line. Plumber use the coupling and union to take the pipes in the same straight line. They don't change the direction of pipes. So that we can say that coupling and union are elbow of 180°.

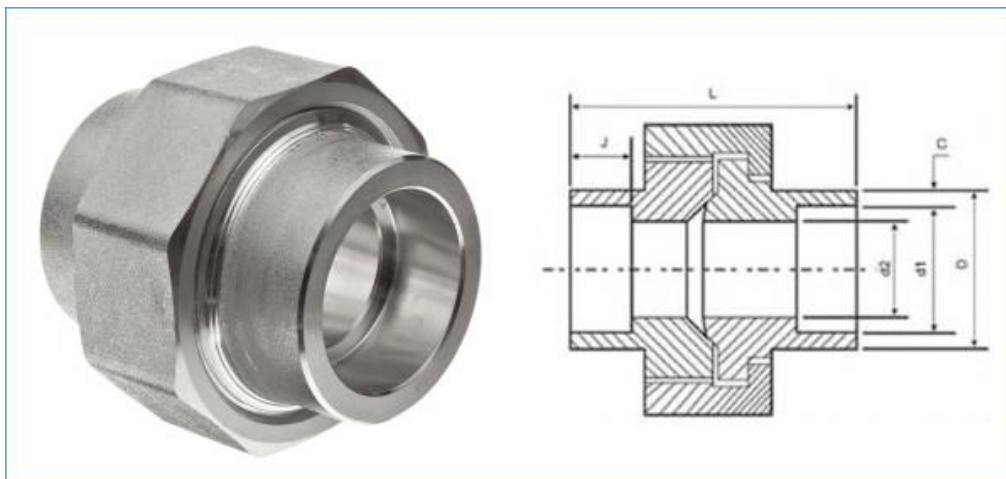


Figure no. 12

Tee: Tees are fittings used to connect two pipes making a branches at 90°. Tees are the combination of elbow of 90° and coupling or union. The plumbers use tee to take one pipe in straight manner and the other in perpendicular. A tee has one input and two outputs. The size

of output may be smaller than that of input. If the size of the output is smaller then, it is known as reducer tee.

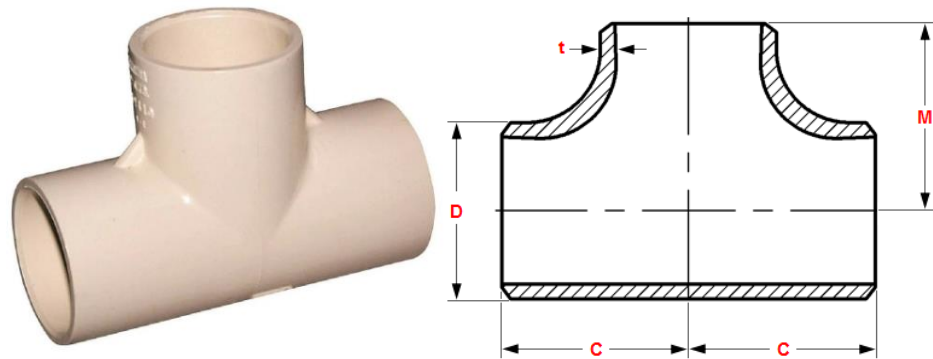


Figure no. 13

Y-bends: Y-bends are used to connect two pipes making branches at 45° . So the Y-bends has one input and two outputs at angle 45° . The plumbers use Y-bends to give the connection of pipes at 45° . The size of output may or may not be equal to the size of input in that case the Y-bend is reducer Y-bend.

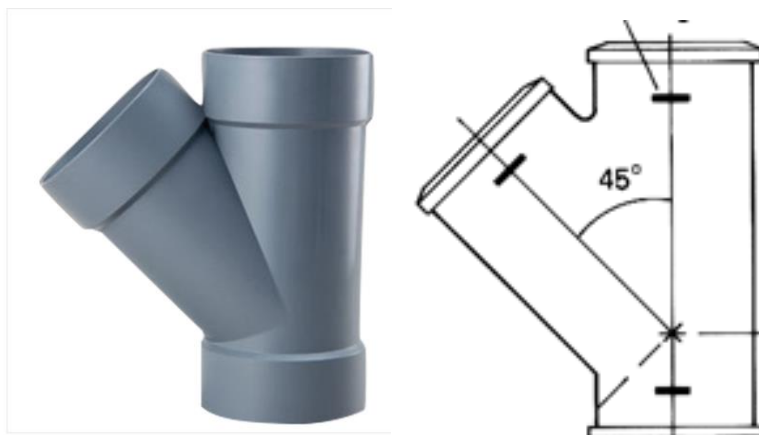


Figure no. 14

Reducer: Reducers are used to connect two pipes reducing the size of pipe. The output pipe is smaller than the input pipe. Reducers are found in the form of tee, unions or in the form of elbow. The plumbers use also reducer to increase the pressure of water in the pipe. There are two types of reducers concentric reducer and eccentric reducer.

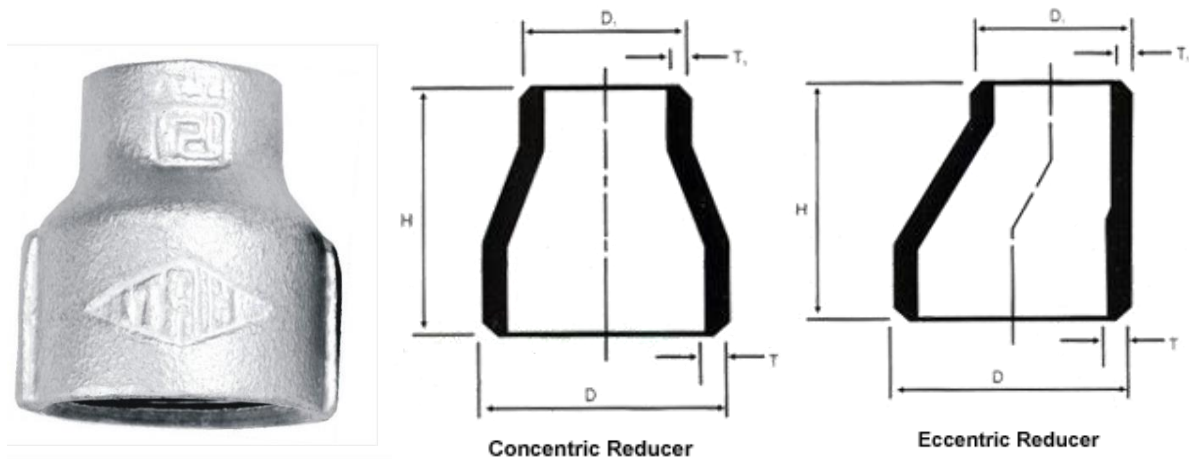


Figure no. 15

Mathematical Concepts used by Plumber

Plumber is also a trade job. As math is a part of trade job so math is also a part of plumber. In fact, basic math and several form of advanced math is used by a plumber. A good plumber not only uses his hand, he used his mind too. In fact, he spends much of his time on troubling shooting problems with water pipes. Plumbers also must be able to read blue print. Algebra and geometry are especially important when it comes to lay out on the job and basic math also comes in handy when a job calls for measuring. In order to accurately complete the measurement, the plumber must also know how to convert a fraction into decimal. While measuring a length of pipe or measuring for fitting it will be important to understand how to convert decimal into fraction. The plumber's ruler utilizes inches and when doing conversion, it will be necessary to take a measurement such as $1\frac{1}{2}$ inches and converting into decimal which in this case would be 1.5 inches.

The Concept of Four Fundamental Operations: According to respondents before taking contract first he calculates the length of pipes required by multiplying the number of floor of the house with its height. The pipes are found in a pieces of fixed length. To calculate the number of pieces required he divides the total length of pipes required by the length of pieces of the pipe. And again to calculate the total cost of pipe he multiplies the rate and number of

pipes. Also he estimates the required number pipe fittings such as elbow, union, valves etc. and their costs.

On the researcher's question what are the shapes of water tank found in the market? They replied two types which are cubical made up of tin and the cylindrical made up of plastic. On the question how do know the capacity of tank they replied multiplying the dimensions of the cubical water tank and multiplying $\frac{1}{4}(\text{diameter} \times \text{diameter} \times \text{height} \times 3.1416)$ for cylindrical water tank. On the observation it is noted that measurement is one of the significant use of mathematics in plumbing. Plumbers should do the accurate measurement of pipes to avoid the waste of pipes. In order to get paid, plumber must know how to calculate his charge hourly rate times the amount of hours he worked. The more mathematical concepts used by plumber are described below:

The Concepts of Measurement: According to the respondents, besides the knowing the benefits and suitability of material in various tasks, a plumber are efficient in measurement of plumbing material with the help of measurement tools and be able to manage conversion of unit easily. Similarly, plumbers also need to be able to understand and read the various symbols used in plumbing drawings. Plumbing material is needed as per the requirement of the plumbing work to be done and its plan. Since, plumbing fitting and fixtures are available in the market in different sizes and types the plumber must have idea of the measurement. The size of plumbing items varies from inch to feet and meter in height. Plumber also must have idea of volumetric capacity like water tank, storage and flush tank etc. It is crucial to have knowledge of various dimensions and sizes of plumbing items for the proper selection and purchasing of plumbing materials in market. A plumber uses the metallic tape, cloth tape, scale and foot ruler for measuring. In order to prevent the waste of pipes also the plumbers need to measure pipes accurately.

The Concept of Fraction: According to the respondents' different size of pipes are used for different purpose and also it depends on the pressure of the water. The size of pipe used in the inlet of water tank is 1 inch to $\frac{3}{2}$ inch. The pipes used in outlet of water tank from where the water is distributed to bathroom and kitchen also varies from 1 inch to $\frac{3}{2}$ inches depends on the size of water tank. The size of pipe used in toilet and bathroom varies from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch. The pipes used in the base floor that is to drained out the water of bathroom varies from 3 inch to 4 inch. The size of pipe used in basin to drained out the water of kitchen varies from 1 inch to 2 inches.

The Concept of Straight: While fittings the pipes on bathroom first they make diagram on the wall to clog the wall. They use rope to make the line straight. When The pipes they used are straight. On the question what would be difficult if the pipes weren't found straight? They reply it would be very difficult to work and manage pipes. Also it would take more pipes and obviously it increases cost. On the researcher's how do you join two pipes in straight manner the respondents replied that they use union to join two pipes in straight manner. Moreover, he added the work of union is to unite two pipes.

The Concept of Angle: On the observation the researcher found that the plumbers use different elbows in order to change the direction of pipes. In order to take the pipe in the destination they have to change the pipes in different direction in different angle. They used the concept of angle to give direction to pipe to reach in specified destination. They change the direction of pipes using elbows of different angles. In order to reach the destination, they have to make right selection of elbow. Here in the following figure two 45° elbows are used in opposite manner so that one angle 45° while other is 135° , the sum is 180° and hence the pipes are parallel.

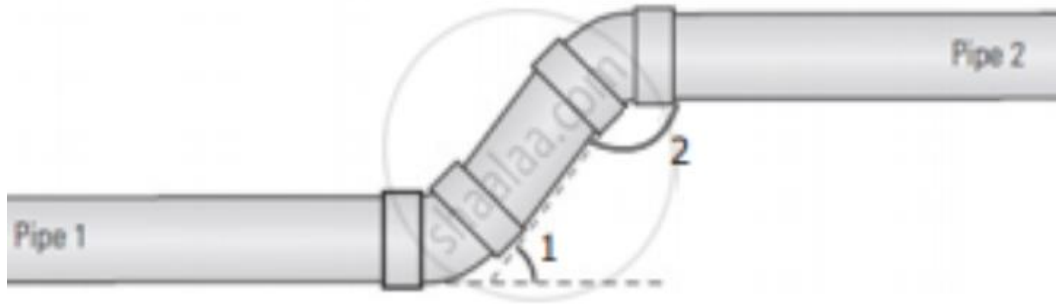


Figure no 16

The Concept of Parallel: On the observation of plumber's activity, it came to know that the plumbers has to take two of more pipes which carries different types of water such as drinking water, cleaning or washing water, hot water etc. along with the wall surface of by grooving the wall. On the researcher's question what do you call for this they replied "sangsangai eknash le lane". On the question how will you make sure the pipes are parallel they replied they make sure the pipes are in equidistant. They usually to take two or more pipes along with wall on parallel manner.

The Concept of Perpendicular: On the observation it is found that they frequently use the concept of perpendicular to join two pipes using 90° elbow. 90° elbows are frequently used to take the pipe from wall to floor and floor to wall. It is also used to give outlet for tap.

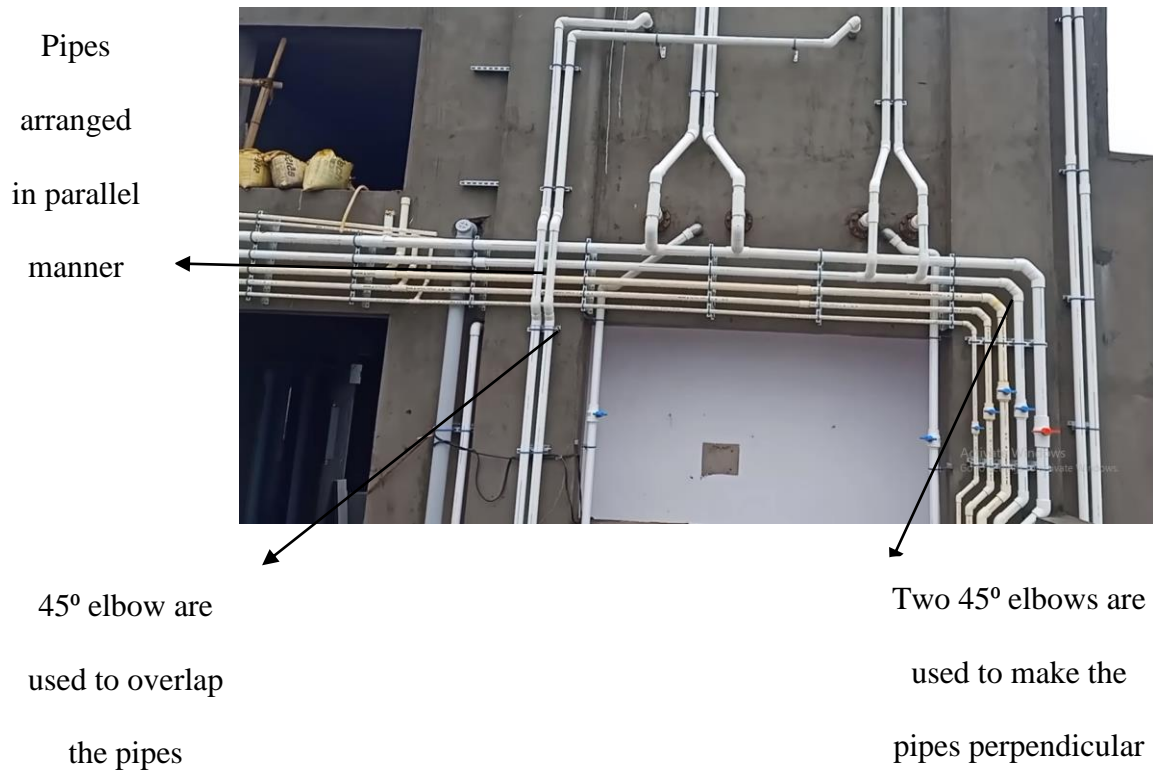


Figure no. 17 (arrangement of pipes)

The mathematical concepts used in the tools and pipe fittings are tabulated below:

S.N.	Name of tools and pipe fittings used	Mathematical concepts used
1	Tube cutter	Tube cutter cuts pipe making parallel and congruent to its opposite base. Here cylindrical pipe is an example of prism and since the surface of pipe cut by the tube cutter are parallel and congruent to its opposite base the cut pipe are also prism.
2	Hacksaw	Hacksaw cuts pipe at any required angle. If the plumber has to make parallel to its opposite base they have make it by their experiences. If they have to join two pipes perpendicularly they have to cut two pipes at 45° and join by them by welding.

3	Hole saw kit	Whole Saw Kit makes circle on metallic surface. It has a cutter on its circular base which cuts the metallic surface while it grinds round. It is especially used to make round hole on metallic water tank to join pipe.
4	Pipe and tube bender	Tube bender bends the metallic pipe making curve at required angle.
5	Compass or divider	Compass or divider are used to measure distance and mark.
6	Plumb bob	Plumb bob is used to make perpendicular surface.
7	Elbows	Elbows are used to change the direction of pipe. Basically two types of elbows 90° and 45° are commonly used.
8	Coupling and union	Coupling and union let pipe goes in the straight manner without changing its direction. Also the reducers reduce the size of pipe. It also increases the pressure of fluid in the pipe if the outlet is smaller the inlet.
9	Tee	Tee is used to give a subway for pipe in perpendicular manner.
10	Y-bend	Y-bend gives a subway for pipe at angle 45° . It is very good example to show 45° angle among students.

Pedagogical Implication of Plumbing in Mathematics Curriculum

The research was done with the objective to suggest the pedagogical implication of plumbing in school. It is appropriate for students, teacher, curriculum designer and other interested persons as well as researcher about the use of mathematics on plumbing which is useful to introduce it into formal mathematics curriculum. It will be more effective if we

introduce this concept in school mathematics. From the short term research the researcher has suggested the following pedagogical implication in school curriculum.

- Pipes are the best example of cylinder, so teacher/curriculum designer can use it to teach the concept of cylinder (i.e. CSA, TSA and Volume of cylinder)
- Different design (rectangle, square, parallelogram, rhombus, triangle) can be made by using the pipes and fittings so it is fruitful to teach such concepts in class.
- Different system of unit length's pipes can be put in the class room so that the students can easily compare the units in different system.
- The angles made by transversal between two straight lines can be shown easily by using the pipe and fittings.
- Pipes are also very good example of straight line. We can use it to teach the concept of straight.
- It is easier to show the length of circumference of circle as a perimeter of circle by measuring the circumference of base of the pipe.
- It can be shown that the ratio of circumference and the diameter is of circle is $\frac{22}{7} = 3.1416$ (approximately) by measuring the circumference and the diameter of base of pipe.

Chapter V

Findings, Conclusion and Suggestions

Findings of the Study

The presented study was an ethnographic study related to mathematical concepts used by a plumber. The objectives of the study were to identify the mathematical knowledge used by plumber and identify how do they acquire the mathematical knowledge. To fulfill these objectives two plumbers from Lalitpur district are taken as respondent, which I took purposefully. From the study of plumbers' work and analyzing the acquisition of their mathematical knowledge, following findings were drawn.

- Plumbers used the fundamental operations of arithmetic while calculating their wages.
- Plumbers used the concepts of measurement while measuring and taking the length and size of pipe.
- Plumbers used the concept of units while taking different sizes of pipes as they are measured in different units according to their sizes.
- Plumbers used the concept of unit conversion as they took different sized pipes.
- Plumbers used the concept of decimal and fraction with whole numbers as the size and length of pipes are not always in whole number.
- Plumbers used the concept of circle and cylinder, size of pipe means the diameter of the circle and length of pipe is height of the cylinder.
- Plumbers used the concept of angles as they used the elbows in different angles in order to change the direction of the fluid.
- Plumbers used the concept of parallel and perpendicular as they have to take two or more pipes along with wall or floor.

- Plumbers use different units such as inch, foot, centimeter and meter according to the situation and also they know the relation among them so that they can convert the one unit to another.

I also find that their ways of acquiring the mathematical concepts, which are as follow:

- The plumbers acquire mathematical knowledge through experiences and practices.
- The mathematical knowledge are socially constructed by the process of communication.
- The plumbers acquire the mathematical knowledge Observing through the peer groups.
- The plumbers acquire the mathematical knowledge through reflection and interaction.

Conclusion

It is concluded that the gaining of knowledge is a process of observing, reflection of thinking, performing, practicing and creating new ideas. To fulfill each and every mathematical needs plumber used applied mathematical concepts knowingly and unknowingly. Lots of knowledge are transferred by their seniors and gained by the process of learning by doing and trial and error method. Skills are gained by drill. Mathematical concepts are gained by cognition and perception of the subject matter. The ideas are gained by active mobilization of their own mind and perception. The gaining of knowledge is a process of reflection and creation. Most of the concepts they frequently used while working were fundamental operation, measurement, cylinder, straight line, angles, perpendicular, parallel, area, volume. They acquired that mathematical knowledge through experiences and practice, observation and social interaction. Thus most of the process of acquiring knowledge are based on Vygotsky's social constructivism.

Suggestions

My experiences with the present research permit me to sound some recommendation and suggestions. Since the ethnographic study was limited in certain aspects of the findings of the study. So consideration this limitation the following suggestions are made.

- It is appropriate for students, teacher, curriculum designer and other interested persons as well as researcher about the use of mathematics on plumbing, which is useful to introduce it into formal mathematics.
- It will be more effective if we can introduce these concepts in school mathematics especially in lower secondary level.

I suggest to all related persons who want to do research in such a style as follows.

Following suggestions have been made for the future research.

- A way of exchanging of mathematical concepts of plumbers.
- A study on the application of geometry for plumbing.
- A study on the role of school math in plumbing.

Educational Implementation

The researcher has mentioned the following education implication of the study.

- It is appropriate for students, teacher, curriculum designer and other interested persons as well as researcher about the use of mathematics on plumbing which is useful to introduce it into formal mathematics curriculum.
- It helps to explore the hidden mathematical concepts by local artist from non-mathematical ways.
- It will be more effective if we introduce this concept in school mathematics.
- It helps students to know the importance and beauty of mathematics.

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Appendix-I: Interview Guidelines for Researcher

Dear sir/madam

Namaste,

I am Sujan Shrestha. I am here for the purpose of data collection to my master research entitled “Mathematical concepts used by Plumber”. I expect you will share your experience without any hesitation. The information you provide will be used exclusively for the study purpose. It will be great help for me if you provide your honest and frank answers to all questions.

Name: Age:..... Sex:.....

Education:..... Address:.....

These themes will serve to generate the question in the interview.

1. For how long are you doing this job?
2. Why did you start the job?
3. How did you get the knowledge required for the job?
4. In what unit size of pipe is measured? Can you convert it into standard unit meter?
5. What is general size of pipe used in house?
6. What is size of pipe used in drainage?
7. What are the shapes of water tank found in market?
8. How do you calculate capacity of the water tank?
9. Can you convert one unit to another? How?
10. Can you convert fraction into decimal and decimal into fractions?
11. How can you ensure sustainability of fittings of the pipes?
12. How do you prevent leakage from the fittings?

Appendix-II: Non-Participant Observation Guidelines for Observer

Dear Sir/Madam

Namaste;

I am Sujan Shrestha. I am here as a purpose of data collection to my masters' thesis entitled "Mathematical Concepts used by Plumber". I request you to accept me as an observer. The information I am collecting here will used the study purpose only. It will be great help for me if you answer in my confusion.

Thank you for your kind co-operation.

Name:

Age:

Sex:

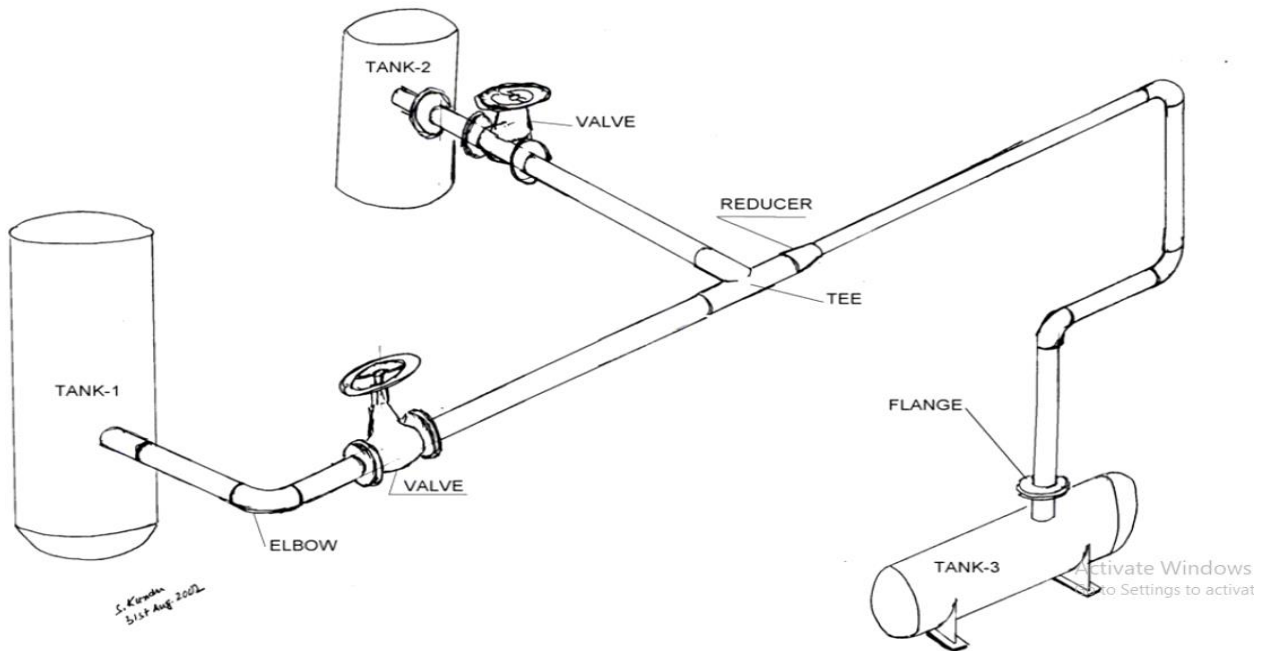
Education:

Address:

The main purpose of this non-participation observation is to know what are the mathematical concepts that the plumber use while doing plumbing work. For this I observe the following activities.

- How they measure size and length of pipes
- How they cut the pipes
- How they use fittings of pipe
- How they calculate area and volume of water tank

Appendix-III: Photographs



Connection of Pipes



Three Mutually Perpendicular connection of pipes