Development of Number System; Hindu-Arabic and Devanagari

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ABSTRACT

Number and symbols are the preliminary study of mathematics learning. This study focuses to investigate the good information about number system. Thus, the main objective of the study was to explore the number perception on human mind and analysis the historical development of Hind-Arabic and Devanagari number system. The research was conducted on the basis of content analysis approach from primary and secondary data. So, design of this research was qualitative research and Historical descriptive.

The source of data for this study were taken from historical documents, archives, websites, research article, related journals, authorized books, consulting with research persons, libraries, department of archaeology etc. The researcher applied open-ended interview with recourse persons to make study strong and valid.What is the origin of number? How to perceive the number in primitive people? And how was the developing phase of the Hindu-Arabic, and Devanagari number system? Be the main problem of this study. The data analysis and interpretation procedure was guided from triangulation process as well as explain analytically, logically, and cross matching comparatively.

At last study concluded, the number is the result of social phenomena. The concept of number and symbols is comes from ancient human culture and human civilization. So, the number is invention from different human civilization but is not from mathematicians. All animal and men have the number sense. Ancient people used concrete objects for notation before the recorded history. Primitive people makes number concept from the define collection of objects. For Eg. "sun" and "moon" for 1, "eyes" and "breast" for 2 and so on. The modern decimal place-value counting was developed from ancient people's one-to-one corresponding counting techniques. The foundation of Devanagari script is ancient Hindu (Nagari) script which was a branch of Brahmi script. Consequently, Hindu-Arabic number is revised form of ancient Hindu (Nagari) number. Moreover, the historical development of number is a way of motivating the learner and see the significance of its further study.

Key Words: *Number System, Number Perception, Hindu-Arabic, Devanagari, Vigesimal Number System, The Sexagesimal system, Manuscript, Numerals, Concrete Numerations, Primitive Counting*

❋ **Writer is independent researcher.**

Introduction

Number is basic and fundamental concept of mathematics on which arithmetic and algebra are developed standing on number through the logical analysis. The number is a sense of ability to recognize quantity of single or collection of objects. Numbers, operation of numbers and their function have occupied important role in mathematics. There developed so many number system in the world, among them Hindu-Arabic, Devanagari, Roman etc. are famous well as useable number system. The ancient Egypt, Babylonian, Greek, China, India, are also famous number system in the world. The ancient Babylonian number system used the sexagesimal(base 60) number system (Boyer, 1968).

First mathematics originated around five thousand years ago along with Egyptian civilization, Babylonian civilization, Greek civilization, Chinese civilization and Hindu civilization (Boyer, 1968). Thousand years ago there is no number to represent two or three. Instead fingers, rocks, sticks, or eyes were used to represent umber. There were neither clocks nor calendar to help keep track of time. Evidence of the fact that mathematics developed in culture and civilization spread into another civilization can be found everywhere (Dantzing, 1930).

Primitive people have well practice and contribution to develop the modern number system. They used different strategies to count the objects. The concept of number and counting developed so long before the time of recorded history and it is imagined that primitive. Human had same number sense of recognizing mane or less objects that have belonged to then, with the gradual development of society, simple counting become inportative (Eves, 1985). Ancient people used simple rally method of counting by employing the, on singer per sheep, goat etc. Letter canting was maintained by making collection of pebbles, sticks or making scratches in the wall or on the stone (Eves, 1985).

According to the book, *The Language of Science* (Dantzing, 1930), many birds have a good number sense. If a nest contains four eggs, one can safely be taken but when two are removed the bird generally deserts. The birds can distinguish two from there. An experiment done with a goldfinch showed the ability to distinguish-piles of seed: There four from three and six from three. The goldfinch almost always confused five and four, seven and five, eight and six, and ten and six (Dantzing, 1930).

In the process of the development of society, it was realized to make mane extensive counts and then gradually the counting had to be systematized. This was done by arranging their numbers onto convenient words, symbols, narrations and groups. Perhaps in the early stages, the vocal or spoken counting was widely used. In addition of vocal numbers, finger numbers and finger signs were used together as well (Boyer, 1976).

Many ancient era and country has deep contributing to developing different numeral system. Mainly, Egypt, Greek, Babylonian, and American civilization has the great contribution on developing the number and numerical system. The Mayan number system dates back to the fourth century and way approximately 1,000 year Mora advanced then the Europeans of that time (McLeish, 1991). His system is unique to our current decimal system is which has base 10, in that the Mayan's used a vigesimal system, which has a base 20. This system is believed to have been used because, since the Mayan's lived in such a warm climate and there was rarely a neat to wear shoes, 20 was the total number of singers and so on. Thus making the system workable.

Babylonians began a numbering system, in about 5,000 years ago (Boyer, 1976). It is one of the oldest numbering systems in ancient country of Babylon, during the third millennium B.C. Tables were the Babylonians must outstanding accomplishment which help them in calculating the problems. One of the Babylonian tablets, Plimpton 322, which is dated between 1900 BC and 1600 BC, contains tables of Pythagorean triples (Jordan, 2009). It is currently in a British museum.

The Babylonian had a very advance number system even for today's standards; it was a base 60 system *(sexagesimal)* rather than a base 10 *(decimal).* Babylonian divided the day into twenty-four hour, each hour into sixty minutes and each minutes into sixty seconds (Jordan, 2009). This form of counting has survived for four thousand years ago.

Hindu-Arabic Number System

Hindu-Arabic number is a decimal place-value number system that consists the numerals 0 to 9. These numbers was first used by Hindu civilization and after Arabian mostly follow. Hindu-Arabic number system first used in about 250-300 B.C by King *Asoka* (Cajori, 1894). This 'number system' was derived from Hindu civilization and transgressing in western society. During this time 'zero' and place-value was not used in Hindu-Arabic number system. The zero was first used in about 825 A.D by Brahamagupta (Menninger, 2013). After, *Al-Khwarizmi* started positional value. The today's numeral zero was taken from Latin word *Zephirum* which means empty (Boyer, 1976). It make easier to take decimal place-value form in Hindu-Arabic number system.

Devanagari Number System

A Sanskrit number system which is representing by symbols; १, २, ३, ४, ५ , ६, ७, ८, ९, and ०. Devanagari is also decimal place-value number system like Hindu-Arabic. This number system is developed from the ancient Nagari script also a branch of Brahmi numeral

(Datta & Sign, 1962). It is a gradual development of the figure from Brahmi numeral in about 6th to 7th century and after it subs oiler in Arab and Alexigendria (Shrestha, 2013).
Number is one of the fundamental concepts of mathematics which developed in ancient time and it has undergone expansion over centuries. Number is so common in mathematics that for many people's number is a synonym of mathematics. In Sanskrit and Nepali languages the term *Ganita* is used to represent *mathematics* whose etymological meaning is the science of counting. According to History of Hindu Mathematics (Datta & Singh, 1935), Ganita is the science of number and counting. Since the number has gone expansion and generalization over centuries, the numbers have extended from finite counting numbers to countable infinite and to uncountable infinite along the line of cardinality due to George Cantor's contribution. On the other hand, the number has extended from counting numbers to rational, irrational and to complex numbers.

The Origin and Discovery of Number

Are animal able to count? The research had been done on the domestic animal. It does happen that a domestic animal a dog, ape, or elephant perceives the disappearance of an object in a restricted ensemble with which it is familiar in many species, the mother shoes by unmistakable sign that she knows that one of her little ones has been taken from her levy Brusl. This another experiment on *goldfish* seen that, chooses food from two small piles of seeds, generally successes in distinguishing three from one, three form two, four from two, four form three and six from three, but nearly allure confuses five and four, seven and five, eight and six, ten and six (Cook, 1997).
Even another remarkable experiment on the crow and the magpie, which are apparently able to distinguish concrete quantities ranking from one to four. At last, the researcher had got conclusion that animal are not able to count. It seems safe to assume that counting is an exclusively human ability closely related to the development of intelligence and involving a mental process more complex than the number sense (Dantzing, 1930).
The study was concern on the main reason that prompted people developed the notation on number. There are still good reasons for believing that, there was a time when people did not know how to count. There does not imply that they had no notation of number, but only that this notion was limited to a kind of number sense, that is, to what direct perception enable them to recognize at a glance. They find number concept was a concrete reality in separable from objects and that is manifested only in direct perception of physical plurality. They were probably unable to conceive of numbers in themselves,

as abstractions. If so, they must not have been aware that such greatest as a brace of hares, the wings of a birds, or eyes, ears, arms, or legs of a person have the common characteristics of "being two".

In the process of development of more complicated society, numbers become eternal components of number symbols should be recorded by this way. Various written number symbols, notations, and other words gradually evolved from these ancient efforts to make permanent number records. Thus, ancient different civilization and culture are the foundation of number.

Number is the sense and symbols are script of mathematics. So, mathematics is the language and body of the numbers. The number and numerals' system is foundation of the mathematics. Number is the essential part of the mathematics as well as human life. So, I would like to study on the basis of *"Development of number system."*

Statement of the Problem

Number is very essential things for human life. It can believe that, primitive people used the numbers but they use their own classical methods. Here, researcher curious about their classical number system and their counting strategy. At all, researcher meets some debate about number perception in primitive people.

The child of fourteen month old has ability to perceive number differences in the people or objects around him or her are very limited when the number goes beyond three or four (Infrah, 1985). Also experiment has shown that, the average people have number sense that is around four (Danting, 1930). Another remarkable experiment shows that, the crow and magic which are apparently able to distinguish concrete quantities ranging from one to four (Dantzing , 1930). So, the George Infrah and Dantzing focused that men and animal have the direct number sense. Men have the direct number sense up to 4 and animal have the different direct number sense. This we, conclude that , men can recognized the collection of objects up to 4 without systematic counting .

Ancient people used materials and objects of all sorts (pebbles, shells, bones, sticks, clay objects), notches in bone or wood, knotted strings, intuitive or conventional gestures' (use of fingers, toes etc.) for counting. The concrete term directly imply the notation of number: "sun", "moon" for 1,"birds wings" for 2, "clover of leaf for 3, "animal legs" for 4, "fingers of one hands" for 5 etc (Ortenzi, 1964).

According to (Ortenzi, 1964), ancient people use the concrete numeral to count the number. They use notches on bones, pebble, shells, sticks and fingers on hands for counting and perceive the number one by the uniqueness of objects like "sun", "moon" etc. Also, two by couple objects, three by unique collection of three objects like tripod,

four by legs of animal etc. This seen controversy to perceive the number in primitive people.

It makes confusion to researcher about perception of the number on primitive people that they count by using their direct number sense or using on concrete objects. Researcher wants to clear about ancient number perception in primitive people and their counting techniques. So, it is a problem in this research.Which number system applies the concept of zero? It is another problem of this research. The Maya were also first to symbolize the concept of nothing (or zero). The Mayan who independently come up with this symbol which meant completion as opposed to zero or nothing (MeLish, 1991).

In 628 CE, astronomer as well as mathematicians Brahmagupta use the number zero and define zero as the result of subtracting a number from itself, postulated negative number and discussed their properties under arithmetical operation (Datta and Sign, 1935). His word for zero was previously used for the empty spot in 9- digit place value system.

This seen controversy that, which number system first carry out the concept of zero. Which number system has the reliable and fact evidence about the discovery of zero, It lead another problem on number system in this research.

The Mayan number system was use around the 4^{th} century and approximately 1000 years of the time to still use. They use vigesimal system, which had base 20 (Ortenzi, 1964). This number uses drive by using gingers and toes. There number was based on multiples of 20. They use $1(20^0)$, $20(20^1)$, $400(20^2)$, $8000(20^3)$ and $160000(20^4)$. In Arabic form we use place values of 1,10,100,1000 and 10000. They used calendar where each month contain 20 day with 18 month to year (Ortazi, 1964).

The Babylonians system of mathematics was sexagesimal (base 60) number system (Boyer, 1968). This system is advance applicable in determine the time on a day they divide the day into twenty- four hour , each hour into sixty minutes , and each minute into sixty seconds . This form of counting has survived for four thousand years (Boyer, 1968).

In ancient time both of number system has parallel importance on that ancient civilization. Maya well discover the systematic vigesimal number system, Eg. Each month contain 20 day with 18 month on a year (Ortazi, 1964). Again, Babylonian formation of the time is still important on now days. The 360^0 on a circle is a still use which was developed standing on sexagesimal number system. Both of number system has well positional value. But regarding on this perspective, new place-value decimal number system take famous place in current day. This number system has advanced application in mathematics. It creates a curious for me. Regarding in this perspective, how to develop the modern decimal place-value number system from ancient primitive counting opposite to famous vigesimal and sexagesimal number system. It was a major

problem in this research. So, I want to search and add more evidence to verify this problem. So, I try to find out the answer of the following questions:

- How to perceive the number in primitive people?
- How was the developing phase of the Hindu-Arabic, and Devanagari number system?

Objective of the Study

The major objective of the study is to explore the number perception on ancient people and to analysis the historical development of *Hindu-Arabic* and *Devangari* number system.

Methodology

This study is guided from content analysis approach. This study has been employed from developing perspective. Researcher explored the number perception on ancient time as well as development of Hindu-Arabic and Devanagari number. So, the design of this study is historical research based on descriptive and analytical approach. The researcher does not manipulate any events and neither control environments. The document analysis, library study, and interview with source person were used on this research. The researcher visited the different libraries, website, consult resource persons and teachers to collect the required information for research. Specially, researcher used the triangulation (multiple methods of data collection and analysis) method to collect the data. The researcher meet the classical documents, lab books, journals, articles, thesis etc.The primary and secondary information are main source of this study. The researcher collected the primary data from visiting manuscripts, inscriptions, biographies and consult with resource persons. Also, researcher collected the secondary data from library, website and other different recorded etc. The required secondary data were; published books and article, journals, records reports, periodicals, bulletins or catalogues, Syllabi, curt decisions, Pictures, micro films, net sides and cartoons etc.

The nature of this study is empirical type. The related data was interpretation in logical, analytical and descriptive manner. The statistical data of classical development are very rare and not match the historical analysis. So, researcher applied the inductive as well as triangulation methods for analysis and interoperation the data. Triangulation is mixing approaches to get two or three views. The information was analysis by crossed matching triangularly *(document, website, interview etc*.) then reached in result. Researcher search common example from different civilization then reach in conclusion by inductive

approach. The study was based on historical documentation and description.Thus, content analysis from primary and secondary data was the main tools of this study.

Finding

Eventually, to provide validation and make verify this research, the interview with resource person was administrated. The researcher prepared an in-depth interview schedule to make valid and authorized the study. The researcher authentic resources persons as; Prof. Dr. Ram Man Sherestha, Prof. Dr. Shankar Raj Pant, Dr. Ek Raj Pandit, Dr. Nilam Subedi and Dr. Eka Ratna Acharya who were provided the well verification in this research, which encourage the researcher to pick up the well finding. The different document analyses, visiting internet sides and consult and interview with recourse persons, the following result have become the major finding of this study:

1. All animal and men has the number sense. The human natural number sense is used for only recognizing the objects. The human's direct number sense is able to recognize the collection of less than four objects at a glance.
2. Numbers are the result of different ancient human culture and civilization not the contributions of mathematicians.
3. Ancient people used concrete objects for notation the number before the recorded history. Primitive people make number concept from define collection of objects. For Eg. “sun” and “moon” for 1, “eyes” and “breast” for 2 and so on.
4. The modern counting was developed from ancient people’s one-to-one corresponding counting techniques.
5. Number symbol is contribution of the human civilization but not the mathematician’s individual achievement. Ancient people used the graphical sign and physical objects to represent the number. They draw this sign on bones, stones, clays, skins, tablets, woods etc. This symbol is continuously used the long time and built digit.
6. The zero was first formulated by Hindu mathematicians Brahmagupta in around 6^{th} to 7^{th} century. But for the first concept of zero, there are controversies up to now.

7. The foundation of Devanagari script is ancient Hindu Nagari script which was a branch of Brahmi script. So, actual foundation of Devanagari script is ancient Brahmi script.
8. Ancient Arya people combine Deva (ancient Sankrit script) with Nagari script than each digit revised into Devanagari script. After formulating the zero by Brahmagupta, Devanagari lead the decimal place-value system.
9. Ancient Brahmi numeral is the foundation of Hindu-Arabic number.
10. Hindu-Arabic number is revised form of ancient Hindu (Nagari) number. Around 10^{th} to 12^{th} century, Indian Devanagari number transgression in Europe and around 13^{th} to 16^{th} century than it revised/modify into modern Hindu-Arabic number.\

Conclusions

The number is the result of social phenomena. Number is birth from daily life necessity of peoples. The concept of number is comes from ancient human culture and human civilization. So, the number is invention from different human civilization but is not from mathematicians. This is resemble regarding on numeral system also. All animal and men have the number sense. The human natural number sense is used for only recognizing the objects. The human direct number sense is able to recognize the collection of less than four objects at a glance. The modern counting is develops from ancient people's one-to-one corresponding counting techniques. Numeral is develops by different graphical sign from ancient people.

The ancient Hindu Brahmi script is the ground script of Devanagari and Hindu-Arabic number system. The decimal place-value Devanagari number system is developing around 5^{th} to 7^{th} century AD. The word Devanagari is formulated by two separated word *Dev*a and *Nagari*. Around 10^{th} to 12^{th} century, Indian Devanagari number transgression in Europe and around 13^{th} to 16^{th} century it revise/modify into modern Hindu-Arabic number.The addition of zero as a tenth positional digit is documented from the 7th century by *Brahmagupta (*Datta and Sign).

Thousands of years ago there were no number to represent one, two, or three. Instead, people used fingers, rocks, Sticks or eyes to represent the numbers. Most civilizations did not have words for numbers larger than two, so they used terminology familiar to them such as flock of sheep, heaps of grain, piles of sticks or stones or groups of people, hair on the head etc. People had little need for a numeric system until they formed clans, villages and settlement and began a system of bartering and trade that in tern created a

demand for currency. Babylonians first drive the numbering system about 5000 years ago (Datta and Sign, 1935). About 500 BCE the Romans developed 9 systems of numerals that used letters from their alphabet rather than special symbols (Example IV for four) (Sherestha, Pp: 5)

Again, the zero was first use in about 825 AD by Al-khwarizmi's then started to positional value (Boyer, 1976). The Bakshali manuscript (4th to 7th century CE), used a place value system without to denote zero. The dot is called the *sunya-sthana*, "empty place" (www.wikipidia.org). Mathematics is develop from three human activities; Counting, categorizing shapes, and measuring (Cooke, 1999 : 5).

Limitations and Future Study

This study is related with the topic "Development of number system". The area of the number is very wider (or not limited). But researcher is so curious on the problem regarding on Hindu-Arabic and Devanagari number system. Thus, area of this study delimitated on developing phase of Hindu-Arabic and Devanagari number system.

The primary and secondary information are main source of this study. The researcher cannot manipulate any event and neither controls the environment. So, the design of this study is bounded on qualitative research and historical descriptive. Researcher collects historical document (journals, article, thesis etc), visit website and administrate in-depth interview and counseling with research resource person. Document analysis was the main methods of this study. Researcher conducts the inductive and triangulation methods for analysis and interpretation the data. So, the tools of this research are delimited on in-depth interview with resource person and document analysis. Interview is delimited with five resource person. This study focuses only on ancient counting and development of Hindu-Arabic and Devanagari number system.

Any of the research doesn't give only new finding but also take out new problem and issues. Research also gives the verification of research technique and methodology. Eventually, on the basis of this study it recommended to the future researcher as *'it should study historical development of Lichhavi numeral system.'*

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