Data Analysis and Interpretations

MEASUREMENTS AND SCALES

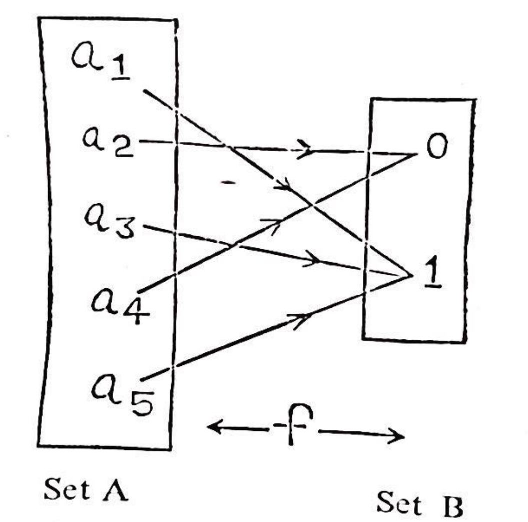
Definition

Measurement is the assignment of numerals to objects or events according to some rules. A numeral is a symbol used to distinguish objects from each other and has no quantitative meaning unless we give such a meaning. In other words, numerals are the symbols assigned to objects according to some prescribed rule. Numerals are usually the symbols 1. 2, 3...or I, II, III...etc ascribed to the objects such as players (Ex: Football players).

When numerals are assigned quantitative meaning, they become numbers. The term assignment means mapping of objects of **one set** onto the objects of **another se**t. A function, f, is the rule of correspondence.

Example 1: Suppose a family consists of five persons and we want to measure their sex. Assuming that we have a prior rule that allows unambiguously to determine the sex, the rule is to assign a symbol if the person is male and another symbol if the person is female. If the symbols used are 1 and 0 respectively, then we have two sets. $A=\{a_1, a_2, a_3, a_4, a_5\}$ and $B=(1, 0\}$ where a_1, a_2, a_3, a_4 and a_5 are the members of the family A.

If the members a_1, a_3 and a_5 are males, then the mapping of the sets will be as:



Thus, measurement may be defined as the mapping of objects of one set to objects of other set.

The kind of measurement achieved is a function of the rule which assigns the numerals (symbols) to objects/observations. The rule is called a **scale**.

Steps in Measurement Procedure

The **first** step in any measurement procedure is to define the objects of the universe of discourse. **Second,** the properties of the objects must be defined. Then the universe `U' is partitioned into at least two mutually exclusive and exhaustive subsets, That is, each object must be assigned to one subset only and all objects must be so assigned.

After the objects of the universe have been classified into designated subsets, the member of the sets can be counted. When set members are counted in this fashion, all objects of a sub-set are considered to be equal to each other and unequal to the members of other sub-sets.

Example: Let U= All tenth grade pupils in a certain high school. Let the measurement characteristics be sex of the pupil. Then U is partitioned into two mutually sub-sets B and G where B is the subset of U which includes all males of U and G is the subset of U which includes all females of U so that U= B+ G

Physical Scales: There are four types of physical scales. They are:

Nominal Scale

A nominal scale is one that allows the researcher to assign subjects to certain categories or groups. This is simplest and lowest form of data and it gives very basic information. This sale is usually used to obtain personal data, where grouping of individuals or objects is required.

EXAMPLE	Gender:	Male, Female
	Religion:	Hindu, Buddhist, Muslim, Christian
	Occupation:	Teacher, Manager, Doctor, Businessman, Civil servant
	Nationality:	Nepali, Indian, American, Japanese
	Department:	Sales, Finance, Personnel, Production

All categories are mutually exclusive. Every respondent has to fit into one of these categories. Therefore, one cannot rank these and say that a male is a higher value than a female, or that 3 teacher has a high value than a manager. Nominal data results from qualitative variables.

The information that can be generated from nominal scaling is to calculate the percentages and frequencies. For example, if you interviewed 150 students in a campus, and assigned a code number 1 to all male students and number 2 to all female students, then computer analysis of data might reveal that 100 were male and 50 were female students. This frequency distribution tells you that 66.6 percent of the respondents are male and 33.4 percent female. Nominal scale, thus, tells you nothing more than basic or gross information. Chi-square test is the most common test applicable to nominal data. Due to its limitations concerning statistical treatment, a nominal scale has the characteristic of exploratory research where the emphasis is on uncovering relationships rather than on specifying the form of relationship.

Ordinal Scale

A scale is ordinal when objects can be assigned order on some characteristic but they cannot be assigned values that represent degree of difference on that characteristic. This scale is usually used to rate the preferences of the respondents. It applies to data which can be ranked according to value but cannot be given a particular numerical value which actually is descriptive of the data. For example, one can rank drinks (coca-cola, tea, coffee, soda water, mineral water) in order of his or her preference from most preferred to least preferred. This means one likes coca-cola better than soda water or prefers coffee to mineral water.

EXAMPLE Rank the following occupations in terms of their social status.

Jobs.	**Rank of Social Status**
Manager	....
Doctor	....
Engineer	....
Professor	....
Lawyer	....
Civil Servant	....
Police Officer	....

In this example, if the respondents give higher rank to doctors than engineers, we can say doctors have relatively higher social status than engineers. We cannot, however, conclude that the doctors have three times higher social status than the engineers.

EXAMPLE Rank the following cities in terms of their suitability to open a branch office of a commercial bank.

Cities	**Rank**
Biratnagar	....
Hetauda	....

Janakpur ....

Butawal . ...

Nepalgunj ....

Dhangadhi ....

Ordinal scales represent numbers, letters, or any symbols used to rank items. The significant amount of business research relies on ordinal measures. The most common usage of ordinal scale is in obtaining preference measurements. For example, the employees of an organization maybe asked to rank their preferences for the newspapers they would like to read, or the games they would like to play. Ordinal scale thus provides more information than the nominal scale.

In ordinal data, median is an appropriate measure of central tendency. Percentile and quartile analysis are used for measuring dispersion. In most cases, rank-order correlations can be used Because of the nature of data; only non-parametric tests can be used.

Interval Scale

This scale assumes that the data have equal intervals. For example, there are five sisters who are all one year apart in age. Radha, Rambha, Reshma, and Rohini are 4, 3, 2 and 1 year older than the youngest sister Rabina. The important point is that we cannot say that the oldest sister Radha is twice as old as Reshma and four times older than Rohini. The reason is that we do not know what the age of the youngest sister, Rabina, is.

Interval scale is like ordinal but with constant intervals. The numbers tell both position and distance. Thus, the interval scale not only groups individuals according to certain categories and taps the order of these groups; it also measures the magnitude of the differences in the performances among the individuals. As such, it is more powerful scale than the nominal and ordinal scales.

Interval scales, or any other attempts at creating such scales, are found often in behavioral research. This is particularly true for measurement of attitudes and certain psychological characteristics, such as intelligence and learning. In analyzing interval data, many options are available. Mean can be appropriately used to measure central tendency. Standard deviation is widely used for dispersion. Product moment correlation can be calculated, and t-test and F•test can be used for significance testing.

Ratio Scale

The ratio scale is the most powerful of the four scales because it has an absolute zero origin and subsumes all the properties of the other three scales. This allows the researcher to calculate the ratio of difference between the age of the individuals. For instance, one can say that the boy who is 8 years old is twice as old as the boy who is 4 years old. Also, we can say that a man who worked 40 hours, worked twice as many hours as the man who worked 20 hours. Some examples of ratio scales are actual age, income, the number of organizations an individual has worked for. The responses could range from 0 to any figure.

EXAMPLE

How many children do you have? ....

What is your annual household income? ....

How many workers are working in your factory? ....

How many workers are the members of the union? ....

What is the highest level of education you have completed? ....

How long have you lived in Kathmandu? ....

Ratio scales are found more commonly in the physical sciences than in the social sciences. Measurement of weight, length, time intervals, area, velocity, etc., all conform to ratio scales. Various types of statistical analysis and mathematical operations can be done on ratio data. Geometric and harmonic means can be used. Likewise, coefficient of variation can be worked out.

अनुसूची- २

General Guidelines for Project Work (PRO 406) Format

It is a mandatory to maintain the uniformity in the format of the Project Work (PRO-406) carried out by B.Sc. IV year students in different departments of several campuses under Institute of Science and Technology (IoST), Tribhuvan University, Nepal.

The format of the Project Work included the following headings/items:

i. Cover Page
ii. Board of Examination and Certificate of Approval
iii. Letter of Forward
iv. Recommendation
v. Declaration
vi. Acknowledgements
vii. Abstract
viii. List of Acronyms and Abbreviations
ix. List of Symbols
x. List of Tables
xi. List of Figures
xii. Table of Contents

1. Chapter 1: Introduction
2. Chapter 2: Literature Review
3. Chapter 3: Materials and Methods
4. Chapter 4: Result and Discussions
5. Chapter 5: Conclusions and Recommendations
6. Reference
7. Appendix

The details of these headings/items are given

विज्ञान तथा प्रविधि अध्ययन संस्थान डीनको कार्यालय कीर्तिपुर २०४५

(Format for cover page)

[TITLE OF THE PROJECT WORK]

(Comment: Center, All caps, Bold, Font size 16)

[Logo of T.U.]

(Comment: Center, size 2"×1.72")

A PROJECT WORK SUBMITTED TO THE

(Comment: Center, All caps, not bold, Font size 14)

DEPARTMENT OF … (Name of Department) ....

…(Name of campus)…… CAMPUS

INSTITUTE OF SCIENCE AND TECHNOLOGY

TRIBHUVAN UNIVERSITY

NEPAL

(Comment: Center, All caps, Bold, Font size 14)

FOR THE AWARD OF

BACHELOR OF SCIENCE (B.Sc.) IN … (Name of subject)….

(Comment: Center, All caps, Bold, Font size 14)

BY

(Comment: Center, All caps, not bold, Font size 14)

[FULL NAME OF THE STUDENT]

SYMBOL No….

T.U. REGISTRATION No…..

(Comment: Center, All caps, Bold, Font size 14

[MONTH, YEAR]

(Comment: Center, All caps, Bold, Font size 14)

RECOMMENDATION

(Comment: Center, All caps, Bold, Font size 16)

This is to recommend that … **(Name of student, bold faced letter)……,** (Symbol No…… , T.U. Registration No……), has carried out project work entitled "…..**(Title, bold faced letter)**……." for the requirement to the project work in Bachelor of Science (B.Sc.) degree in …(Name of subject)………… under my/our supervision in the Department of …… (Name of department)……, …(Name of Campus/Institute)… Campus, Institute of Science and Technology (IoST), Tribhuvan University (T.U.), Nepal.

To my/our knowledge, this work has not been submitted for any other degree.

He/She has fulfilled all the requirements laid down by the Institute of Science and Technology (IoST), Tribhuvan University (T.U.), Nepal for the submission of the project work for the partial fulfillment of Bachelor of Science (B.Sc.) degree.

(Comment: Times New Roman, Font size 12)

…. (Name) ….
Supervisor
Department:
Campus/Institute:
University:

…. (Name) ….
Co-Supervisor
Department:
Campus/Institute:
University:

विज्ञान तथा प्रविधि अध्ययन संस्थान
डीनको कार्यालय
कीर्तिपुर

[DAY, MONTH, YEAR]

DECLARATION

(Comment: Center, All caps, Bold, Font size 16)

This project work entitled "… **(Title, bold faced letter)** ….." is being submitted to the Department of …(Name of department)…., …(Name of Campus)…… Campus, Institute of Science and Technology (IoST), Tribhuvan University (T.U.), Nepal for the partial fulfillment of the requirement to the project work in Bachelor of Science (B.Sc.) degree in …(Name of subject)…. This project work is carried out by me under the supervision of ….(Name of supervisor)…… and co-supervision of …..(Name of co-supervisor)…… in the Department of …… (Name of department)……, … (Name of Campus/Institute) …… Campus, Institute of Science and Technology (IoST), Tribhuvan University (T.U.), Nepal.

This work is original and has not been submitted earlier in part or full in this or any other form to any university or institute, here or elsewhere, for the award of any degree.

(Comment: Times New Roman, Font size 12)

Signature

Name of student

Symbol No. ……..

T.U. Registration No……

[DAY, MONTH, YEAR]

LETTER OF FORWARD

(Comment: Center, All caps, Bold, Font size 16)

[Date: Day/Month/Year]

On the recommendation of **…… (name of supervisor, bold faced letter) …..** and **…… (name of co-supervisor, bold faced letter) …..**, this project work is submitted by **…… (name of student)…..**, Symbol No. ….., T.U. Registration No……., entitled **…….(title, in bold faced letter)**…….” is forwarded by the Department of … (Name of department)……, …(Name of Campus)…..Campus, for the approval to the Evaluation Committee, Institute of Science and Technology (IoST), Tribhuvan University (T.U.), Nepal

He/She has fulfilled all the requirements laid down by the Institute of Science and Technology (IoST), Tribhuvan University (T.U.), Nepal for the project work.

(Comment: Times New Roman, Font size 12)

…. (Name) ….
Head of Department
Department of …….
……… Campus
Tribhuvan University

विज्ञान तथा प्रविधि अध्ययन संस्थान
डीनको कार्यालय
कीर्तिपुर २०४५

BOARD OF EXAMINATION AND CERTIFICATE OF APPROVAL

(Comment: Center, All caps, Bold, Font size 16)

This project work (PRO-406) entitled "**…(Title, bold faced letter)….**" by …(Name of student)…. (Symbol No………and T.U. Registration No…………………..) under the supervision of ….(Name of supervisor)…… and co-supervision of …..(Name of co-supervisor)…… in the Department of ……(Name of department)…., -…(Name of Campus)…..Campus, Institute of Science and Technology (IoST), Tribhuvan University (T.U.), is hereby submitted for the partial fulfillment of the Bachelor of Science (B.Sc.) degree in …(Name of subject)…. This report has been accepted and forwarded to the Controller of Examination, Institute of Science and Technology, Tribhuvan University, Nepal for the legal procedure.

(Comment: Times New Roman, Font size 12)

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…. (Name) ….….	**….. (Name) ….**
Supervisor	**Co-Supervisor**
Department:	Department:
Campus/Institute:	Campus/Institute:
University:	University:

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…. (Name) ….	**…. (Name) ….**
External Examiner	**Internal Examiner**
Department:	Department:
Campus/Institute:	Campus/Institute:
University:	University:

…. (Name) ….

Head of Department

Department of …….

……………… Campus

Tribhuvan University

[DAY, MONTH, YEAR]

विज्ञान तथा प्रविधि अध्ययन संस्थान
डीनको कार्यालय
कीर्तिपुर

ACKNOWLEDGEMENTS

(Comment: Center, All caps, Bold, Font size 16)

Text: (Times New Roman, Font size 12)
No. of pages: (Not more than 2 pages, write in justified form)

(Comment: Times New Roman, Font size 12, spacing within a paragraph 1.5, spacing between two paragraph 2.0)

(Name of student)
Symbol. No. …
T.U. Registration No……..
[Month, Year]

विज्ञान तथा प्रविधि अध्ययन संस्थान
डीनको कार्यालय
कीर्तिपुर

ABSTRACT

(Comment: Center, All caps, Bold, Font size 16)

Text: (Times New Roman, Font size 12)
No. of pages: (preferable within a page, write in justified form)

(Comment: Times New Roman, Font size 12)

Keywords (**Comment:** Times New Roman, Font size 10, Italics)**: …., …., …., …., …. (Comment:** Write five keywords, Times New Roman, Font size 10, not in Italics).

शोधसार (अनिवार्य)

(टिप्पणी: मध्य, **बाक्लो,** प्रीति, १८)

मुल पाठ: (प्रीति, १६)
पाना संख्या : (एक पानाभित्र समेटिने गरी लेख्नुपर्ने)

(टिप्पणी: हरफ मिलेको, प्रीति, १६)

Keywords (**Comment:** Times New Roman, Font size 10, Italics)**: …., …., …., …., …. (Comment:** Write five keywords, Times New Roman, Font size 10, not in Italics).

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डीनको कार्यालय
कीर्तिपुर

LIST OF ACRONYMS AND ABBREVIATIONS

(Comment: Center, All caps, Bold, Font size 16)

Text: (Times New Roman, Font size 12)
Examples:

FTIR:	Fourier Transforms Infrared Spectroscopy
GC-MS:	Gas Chromatography-Mass Spectroscopy
LPG:	Liquefied Petroleum Gases
NGO:	National Governmental Organization

(Comment: Times New Roman, Font size 12, line spacing 1.5, arrange in alphabetical order)

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कीर्तिपुर २०४५

LIST OF SYMBOLS

(Comment: Center, All caps, Bold, Font size 16)

Text: (Times New Roman, Font size 12)
Examples:

μ	Dipole moment
γ	Activity Coefficient
ε	Relative Dielectric Constant

(Comment: Times New Roman, Font size 12, line spacing 1.5)

LIST OF TABLES

(Comment: Center, All caps, Bold, Font size 16)

Text: (Times New Roman, Font size 12)

Table No (bold faced letter): Title of the table (not bold, font size 12) **Page No.**

Examples:

(Comment: Times New Roman, Font size 12, line spacing 1.5)

LIST OF FIGURES

(Comment: Center, All caps, Bold, Font size 16)

Text: (Times New Roman, Font size 12)

Figure No (bold faced letter): Title of the figure (not bold, font size 12) **Page No.**

Examples:

(Comment: Times New Roman, Font size 12, line spacing 1.5)

TABLE OF CONTENTS

(Comment: Center, All caps, Bold, Font size 16)

Text: (Times New Roman, Font size 12)

(**Comment:** Times New Roman, Font size 12, line spacing 1.5)

CHAPTER 1

(All caps, bold faced letter, Font size 16)

1. INTRODUCTION (All caps, bold letter, Font size 14)

1.1 General Introduction (Bold, Font size 12)

(Text: Times New Roman, Font size 12, not bold)

1.2 Rationale (Bold, Font size 12)

(Text: Times New Roman, Font size 12, not bold)

1.3 Objectives (Bold, Font size 12)

1.3.1 General objective: (Bold, Font size 12)

(Text: Times New Roman, Font size 12, not bold)

1.3.2 Specific objectives: (Bold, Font size 12)

(Text: Times New Roman, Font size 12, not bold)

CHAPTER 2

(All caps, bold faced letter, Font size 16)

2. LITERATURE REVIEW (All caps, bold letter, Font size 14)

2.1 (Sub-heading, if any) (Bold, Font size 12)

(Text: Times New Roman, Font size 12, not bold)

2.2 (Sub-heading, if any) (Bold, Font size 12)

(Text: Times New Roman, Font size 12, not bold)

CHAPTER 3

(All caps, bold faced letter, Font size 16)

3. MATERIALS AND METHODS (All caps, bold letter, Font size 14)

3.1 Materials

3.1.1 (Sub-heading, if any) (Bold, font size 12)

(Text: Times New Roman, Font size 12, not bold)

3.1.2 (Sub-heading, if any) (Bold, font size 12)

(Text: Times New Roman, Font size 12, not bold)

3.2 Methods:

3.2.1 (Sub-heading, if any) (Bold, Font size 12)

(Text: Times New Roman, Font size 12, not bold)

3.2.2 (Sub-heading, if any) (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)

CHAPTER 4
(All caps, bold faced letter, Font size 16)

4. RESULTS AND DISCUSSION (All caps, bold letter, Font size 14)

4.1 (Sub-heading, if any) (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)

4.2 (Sub-heading, if any) (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)

CHAPTER 5
(All caps, bold faced letter, Font size 16)

5. CONCLUSION AND RECOMMENDATION (All caps, bold letter, Font size 14)

5.1 Conclusions (Bold, Font size 12)
5.1.1 (Sub-heading, if any) (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)
5.1.2 (Sub-heading, if any) (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)

5.2 Novelty and National Prosperity aspect of Project work (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)

5.3 Limitations of the work (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)

5.4 Recommendations for further work (Bold, Font size 12)
(Text: Times New Roman, Font size 12, not bold)

REFERENCE
(All caps, bold faced letter, Font size 16)

APPENDIX
(All caps, bold faced letter, Font size 16)
(Scientific publication, questionnaires, long computational algorithms, if necessary)

(Comment: Times New Roman, Font size 12, spacing through body of text 1.5 spacing, 1.5 spacing within each entry but 2.0 spacing between each entry)

Note: Project work for some of the departments (Mathematics, Statistic) may not fit into the above mentioned patterns, for such situations, the body part of the project work should have the following order.

a) **Introduction**
b) **Chapters with special heading, which covers the project work performed by the student.**
c) **Summary and conclusions: It includes the overall summary, conclusions and the recommendation for further work, if applicable.**

Language of Project work:

- The project work must be written in English.
- Presentation of the project work in viva-voce examination should also be conducted in English medium.

Length and quality of printing of Project work:

- The project work should be printed in single sided white bond paper of A4 size with body text not less than 30 pages.
- Photocopy of printing is not acceptable.

Typeface and font size:

- The project work should be written in Times New Roman.
- The font size should be 12 throughout the text except as mentioned above.
- Equations and formulae should be preferably written in 10 font size.
- The scientific names should be written in italics.
- The text should be justified.

Tables and Figures:

- Tables and figures should appear in the text closely to the point where it is first discussed.
- Table number and its heading should be placed above the body of the table.
- Figure number and its heading should be placed below the body of the figure.
- The font size for both table and figure caption should be 10.
- Table number and figure number must be continuous in the report.
- Table number and figure number are written in bold faced letter while their titles are written not in bold.
  Examples:
  Table 1 (font 10, bold): …..Title (font 10, not bold)…….
  Figure 1 (font 10, bold): …..Title (font 10, not bold)…….

Margins:

- In printing- top, right and bottom margins should be 2.5 cm and left margin should not be less than 3.5 cm.
- Page number should be at least 1.5 cm above from the lower edge of the paper.

Spacing:

- Spacing for text: 1.5 spacing throughout the body of text
- Spacing for references: 1.5 spacing within each entry and 2.0 spacing between each entry.

Pagination:

- Every page has a number.
- Use small Roman numerals (i, ii, iii, …..) for the preliminary pages such as *Board of Examination and Certificate of Approval*, *declaration, certificate of approval, table of contents etc.*
- Count the inner cover page as page i and the other pages such as *Board of Examination and Certificate of Approval, declaration, certificate of approval, table of contents etc.* ii, iii, iv, …. etc.
- Do not print the page number on inner cover page.
- Use Arabic Hindu numbers (1, 2, 3, 4, …) starting with page 1 from chapter 1.

Reference and citation in the text:

- American Psychological Association (APA) format should be preferably followed for references and citations in the text. The references should be arranged in alphabetical with chronological order by surname of the first author. Spacing for references should be 1.5 within each entry but double spacing between each entry. Use hanging indents: entries should begin flush left with subsequent lines indented.
- Other standard format such as AMS (American Mathematical Society), AIP (American Institute of Physics), ACS (American Chemical Society), etc. can also be accepted.
- Every reference cited in the text and present in the reference list should be linked and synchronize in standard reference management program such as EndNote, Latex, Zotero etc.

Examples of using APA format in reference and citation:

i) Book of single author:

Surname, Initial uppercase letter of author's name (Year), Title of the Book, Place, Publication.

Barron L. D. (1983), *Molecular Light Scattering and Optical Activity*, Cambridge University Press, Cambridge, UK.

Citation in the text: (Barron, 1983) or Barron (1983) explained …….

ii) Book of two authors:

Gosney, I. & Rowley, A. G. (1979), "Transformations via Phosphorus-stabilized Anions, Stereoselective Synthesis of Alkenes via the Wittig reaction", *Organophosphorus Reagents in Organic Synthesis*, Academic, New York, p.17.

Citation in the text: (Gosney & Rowley, 1979) or Gosney and Rowley (1979) stated that……

iii) Book of three or more authors:

Pelter, A., Smith, K., & Brown, H. C. (1988), *Borane Reagents*, Academic, London

Citation in the text: (Pelter, *et al.*, 1988) or Pelter, *et al.* (1988) explained …….

iv) Journal of single author:

Evans, D. A. (1982), “Studies in Asymmetric Synthesis. The Development of Practical Chiral Enolate Synthons,” *Aldrichin. Acta*, **15**, 23

Citation in the text: (Evans, 1982) or Evans (1982) explained …….

v) Journal of two authors:

Denmark, S. E., & Marble, L. K. (1990), “Auxillary-Based, Asymmetric SN_2’ Reactions: A Case of 1,7-Relative Stereogenesis,” *J. Org. Chem.,* **55**, 1984

Citation in the text: (Denmark and Marble, 1990) or Denmark and Marble (1990) highlighted ……

vi) Journal of three or more authors:

Gautam, D. R., Protopappas, J., Fylaktakidou, K. C., Litinas, K. E., Nicolaides, D. N., and Tsoleridis, C. A. (2009), *Tetrahedron Lett.,* **50**, 448.

Citation in the text: (Gautam, *et al.*, 2009) or Gautam, *et al.* (2009) found that …….

Note: The names of journals should be typed in italic exactly as the name of the journal examples: *J. Am. Chem. Soc., J. Org. Chem., J. Am. Stat Assoc., Tetrahedron Lett., etc.*

vii) Ph.D/Master’s Dissertation:

Rajbhandari (Nyachhyon), A. (2011), *Investigation on Inorganic Salts based Ions Selective Electrodes* (Unpublished doctoral thesis). Central Department of Chemistry, Institute of Science and Technology, Tribhuvan University, Kathmandu, Nepal.

viii) Internet article with DOI assigned:

Stultz, J. (2006), Integrating exposure therapy and analytic therapy in trauma treatment. *American Journal of Orthopsychiatry*, **76** (4), 482-488, doi:10.1037/0002-9432.76.4.482

In case of more than 7 authorships, author can be used *et al*. in the text and reference respectively. For example

Van Decar, J. C., Russo, R. M., James, D. E. *et al*. (2003). A seismic continuation of the Lesser Antilles slab beneath northeastern Venezuela. *Journal of Geophysical Research*, **70** (3), 212-219, doi.org/10.1029/2001JB000884

ix) Internet article without DOI assigned:

Sillick, T. J. & Schutte, N. S. (2006), Emotional intelligence and self-esteem mediate between perceived early parental love and adult happiness. *E-Journal of Applied Psychology*, **2** (2), 38-48. Retrieved from http://ojs.lib.swin.edu.au/index.php/ejap/article/view/71/100, Accessed on (dd/mm/yy).

अनुसूची– ३ (क)

………….. Campus

Department of ………….

Institute of Science and Technology, Tribhuvan University

Project Work Evaluation Form

Name of Student:

Title of Project work:

Course Code: PRO-406 Symbol No.: Date: ……/..…/…

Evaluation Scheme

10	Extraordinary	9	Excellent	8	Very Good
7	Good	6	Average	5	Poor

Evaluation Criteria	**Evaluation (Circle One)**						**Total Evaluated Number**
Novelty	10	9	8	7	6	5	
Problem of Identification	10	9	8	7	6	5	
Project Design	10	9	8	7	6	5	
Procedure, Data collection and analysis	10	9	8	7	6	5	
Conclusion and Future works	10	9	8	7	6	5	
Literature review	10	9	8	7	6	5	
Writing format	10	9	8	7	6	5	
Presentation	10	9	8	7	6	5	
Viva-voce Performance	10	9	8	7	6	5	
Social Impact	10	9	8	7	6	5	

Additional Comments (If any):

$$Marksobtained = \frac{TotalEvaluatedNumber}{100} \times FullMarksoftheExaminer = ¿$$

[F.M. for out of 100: Supervisor (40)/ External Examiner (25)/ Internal Examiner (20)/ Head of the Department (15)]

Name:

Signature:

Date:

Supervisor/External Examiner/Internal Examiner/Head of the Department

विज्ञान तथा प्रविधि अध्ययन संस्थान
डीनको कार्यालय
कीर्तिपुर २०७५

<u>अनुसूची– ३ (ख)</u>

Mark ledger of the Project work student

Date: ……/…/…

To,
The Office of the Controller of Examination,
B. Sc. Exam Section,
Tribhuvan University,
Balkhu, Kathmandu, Nepal.

<u>Subject: Marks of B. Sc. Project work (PRO 406)</u>

Sir,

Marks obtained by Mr./Ms. ………………..……….. (Batch ……..) for the evaluation of Project work conducted at the Department of ……………., ……………………. Campus for the partial fulfillment of B. Sc. in ……… has been forwarded. The details are as follows:

Year: Fourth **Course Code:** PRO 406
Full Marks: 100 **Pass Marks: 50**

Title of Project work:

Date of Submission : …………………….. (BS)/ ……………………… (AD)
Date of Viva-voce : ……………………… (BS)/ ……………………… (AD)

S.N.	Symbol No.	Regtistration No.	Name of Student	Marks obtained (In figure and words)
1.				

Name and Signature of the members of Project work Evaluation committee/Board:

	Name	Signature
Supervisor :		
Co-Supervisor :		
External Examiner :		
Internal Examiner :		
Head of the Department :		

…………..……………….
(Name)
Head of the Department
………… Campus

विज्ञान तथा प्रविधि अध्ययन संस्थान
डीनको कार्यालय
कीर्तिपुर २०७५

Note: Dean Office has formed a committee to revise '*B.Sc. Fourth Year Project Work (PRO 406) Guideline*' under the convener-ship of **Prof. Dr. Daman Raj Gautam** (Amrit Campus) on 2078/01/15. The members of the committee were **Mr. Iswar Koirala** (Tri-Chandra Campus) and **Dr. Binod Baniya** (Patan Multiple College). The report was submitted to the Dean Office on 2078/02/14. Dean Office has tabled the report in the Full Faculty Board Meeting (virtual) on 2078/03/11. This '*B.Sc. Fourth Year Project Work (PRO 406) Guideline 2078*' has been approved by the faculty Board (Full) meeting on 2078/03/11.

विज्ञान तथा प्रविधि अध्ययन संस्थान
डीनको कार्यालय
कीर्तिपुर

Dissertation

Code No.: MDS699

Course Title: Dissertation **Full Marks:** 150

Nature: Dissertation **Credit:** 6

Course Description:

Dissertation is a formal piece of academic writing required for the completion of Master's degree in Data Science program. The final and central requirement for awarding the degree is the completion of substantial and original independent dissertation research in the data science field. Dissertation is a research paper of full marks 150 offered in 4^{th} semester of the program. It represents the culmination of a student's research and scholarly work in a particular field of data science. The purpose of this course is to contribute new knowledge, insights, or perspectives to the academic community and is expected to present original research and in-depth analysis of the chosen topic.

Course Objective:

The main objective of this course is to familiarize students with the skills needed to conduct in-depth study in the data science field to conduct an original research and contribute new knowledge to the data science community.

Learning Outcomes:

Upon successful completion of this course, students will be able to:

1. design and conduct an original research in the data science field,
2. contribute new knowledge to the academic community in the relevant field,
3. apply different theoretical concepts taught in the class in the chosen topic, and
4. conduct in-dept analysis of the chosen topic and enhance their research skills.

Phases:

The overall dissertation work is divided into three phases, proposal defense, pre-defense, and final defense.

1. **Proposal Defense**

   Each student must prepare a document in the prescribed proposal format proposing a specific plan for her or his dissertation research. This document is expected to make a convincing case that the proposed research is likely to make an original contribution. Students must present the research proposal in the research committee. Once accepted from the research committee, students can start their work under the supervision of a supervisor assigned from the research committee.

2. **Pre-Defense**

   Each student must prepare draft of the dissertation report and present this report in the research committee before final defense. Once approved from the research committee, students will be allowed to participate in the final defense. Each member of the committee members can advise the student about major revisions and additions to the tasks of research.

3. **Final Defense**

   During final defense, each student must prepare a final report in the prescribed format and present this final report. Students are expected to explain the significance of the dissertation research, justify the methods employed, and defend the conclusions reached. The overall dissertation work will be evaluated during final defense by the school director, an external examiner, the supervisor, and an internal examiner. The external examiner will be appointed from Institute of Science and Technology and the internal examiner will be appointed by the school director.

Activities:

The different activities and steps involved in the dissertation research are:

- Select the research topic
- Prepare and present research proposal
- Do the research and draw conclusion
- Prepare and present draft report
- Prepare and present final report

Proposal Structure:

The dissertation proposal document generally follows the following structure:

- Title Page
- Introduction
- Problem Statement
- Objectives
- Rational of the Study
- Preliminary Literature Review
- Methodology
- Expected Outcomes
- Working Schedule
- References

Final Report Structure:

The final report of the dissertation generally follows the following structure:

- Title Page
- Student’s Declaration
- Supervisor’s Recommendation
- Approval Sheet
- Acknowledgement
- Abstract
- Table of Contents
- List of Figures
- List of Tables
- List of Abbreviations / Acronyms
- Introduction (Chapter 1)
- Literature Review (Chapter 2)
- Methodology (Chapter 3)
- Result and Discussion (Chapter 4)
- Conclusion and Recommendation (Chapter 5)

- References
- Appendices

Needs of Scaling

Scales are such which can be used in quantifying every measurable property of objects or the variables. To measure the physical phenomena different kinds of scales are to be needed. The method of scaling is the technique of turning a series of qualitative facts into a quantitative series. The main needs of scaling techniques are:

(1) **For attaining scientific maturity**: The fundamental form of the movement in the direction of the greater precision is measuring graduation of the objects for a scientific study. Hence, the scaling technique is for the scientific maturity.

(2) **For objective measurement**: The scaling techniques are very useful in technical and social studies and the reliable inference about the technical/social phenomenon can be drawn by the use of the objective measurement.

(3) **For the improvement of more precise measuring device**: The existing measuring instrument and techniques can be improved by the use of different scales. More precise measuring devices are developed through the scientific use and practice of the existing scales.

Characteristics of a Scale

The essential characteristics of a good scale are:

a**) Continuum** **b) Reliability** **c) Validity** **d) Practicability**

Continuum

It is the characteristics of scale that it should be in the form of continuous series and the factors to be measured interrelated. The continuum to be defined depends upon the nature of the phenomenon and the nature of the factors to be defined.

Reliability

To obtain consistent result the measuring instrument should be steadfast. The reliability of the measuring scale must be stable, consistent and the error function should be correctly defined. It means the stability, consistency, dependability, predictability and accuracy of the scale used. According to Ebil 'The term reliability means the consistency with which set of test scores measure whatever they do measure'.

Definition

a) If we get the same measuring result for the same object / observation in many times then the measure (scale) may be considered as reliable measure (scale).

b) The absence of measurement error in measuring instrument is the reliability of the measure.

Validity

The most critical criterion of the scaling technique is the validity. A scale is said to be valid when it measures correctly what is expected to be measure. In other words, validity is the extent (degree) to which differences found with a measuring instrument reflect true difference among those being tested.

In experimentation, **reliability** is the extent to which the measurements resulting from a test reflect characteristics of the subject of measurement. An experiment is reliable if we are getting consistent results from the same measure. It is unreliable if repeat measurements of the same thing give different results.

In statistics a valid measure is one which is measuring what it is supposed to measure. **Validity** implies reliability (accuracy). A valid measure must be reliable, but a reliable measure may not be valid.

Practicability

It is the characteristics of the measure that must be practicable to use. It should be reasonable economically, conveniently and interpretably. It should be easy to administer. The scales used must be supplemented by i) detailed instruction of handling ii) scoring techniques (keys) iii) guides for utilize and iv) evidence about reliability.

Methods of Estimating Reliability (Tests of Reliability)

To obtain the reliability of the different scores, the following four method of computing reliability, coefficient are used.

a) Test- retests Method

b) Parallel/Alternate/Equivalent forms Method

c) Split Half Method

d) Rational Equivalence Method (Kuder Richardson Method)

(a) **Test-retest Method**

In this method the same set of objects/ items is measured (tested) again and again by using the same or the comparable measuring instrument. The results so obtain are compared by computing correlation coefficient between the scores of the different tests (measures). If it is impossible to use such method due to the long space of time, it is considered whether the effects of causative factor in the period of two tests are present or not. To find the result related to this problem technique of control group (a team checking by trained and motivated persons) is applied.

(b) **Parallel Forms Method**

In this method two analogous forms of test-scales are constructed and alternatively applied to the same samples/items selected/objects selected. The analogous forms mean the alternate or parallel forms of the tests having of the same kind difficulty category and design. To obtain the reliability coefficient the correlation coefficient between the test-results is computed. If the results are in high degree of connection then the scale may be said to be reliable. The correlation of the forms is called self-correlation and it becomes an index of equivalence of two sets. The parallel forms are mostly useful for the standard psychological and educational achievement tests.

(c) Split half Method

In this method the scores are divided in two equal parts randomly. For example, the scores on odd no. of test-set as a first half and the scores on even no. of test-set as the other half. Considering a part as complete, scaling procedure is applied for these two half-parts. If there exists a high degree of correlation between the scores of these halves, then the scaling is considered to be reliable. The split half method is generally used when it is difficult to construct the parallel form test. The coefficient of internal consistency or the self-correlation coefficient of the whole test is called Stepped up reliability and estimated by using Spearman-Brown formula. The general formula is

$$Rw = \frac{n*r_p}{1+(n-1)r_p}$$

Where, R_w is stepped up reliability coefficient; n the number of parts

r_p = the correlation coefficient between two parts

Spearman- Brown formula for computing test reliability having two halves is

$$R_{xy} = \frac{2\times r_{xy}}{1+r_{xy}}$$

Where,

R_{xy} = Stepped up reliability coefficient of first and second half

2 is the number of parts and

r_{xy} = The correlation coefficient between two parts X and Y.

If the score are expressed in the ranks then, correlation coefficient is calculated by

$r_{xy} = 1 - \frac{6\Sigma d^2}{n(n^2 -1)}$, Which is called Spearman's Rank correlation Coefficient?

If the scores are in the numeric scale then, correlation coefficient is calculated by,

$$r_{xy} = \frac{n\Sigma XY - \Sigma X \times \Sigma Y}{\sqrt{nY^2 - (\Sigma Y)^2}\sqrt{n\Sigma X^2 - (\Sigma X)^2}}$$

Which is called Karl Pearson's coefficient of correlation, where, X represent the scores of the first half and Y the scores on the second set.

Example

A test-score is divided in two halves as the scores on the odd numbered questions and the scores on the even numbered questions. The correlation coefficient between them is obtained as 0.72, what is the reliability coefficient of the whole test.

Solution

Here, Correlation coefficient (r_{xy}) = 0.72

n = 2

Reliability coefficient, $R_{xy} = \frac{2 \times r_{xy}}{1 + r_{xy}} = \frac{2 \times 0.72}{1 + 0.72}$ = 0.8272

The reliability coefficient is 82.72%; the dependability of the whole score seems to be very good.

d) Rational Equivalence Method (Kuder-Richardson Method)

Two forms of a test are defined as equivalence when corresponding items are interchangeable and inter item correlation is same for both forms. Kuder-Richardson method is the method of obtaining reliability by using the internal consistency between the measures (questions) of the same scaling (test). The reliability coefficient for this method is obtained by the following two formulae. Kuder-Richardson's first formula for reliability is denoted by KR_1, is computed as

$KR_1 = R_w = \frac{n}{n-1}\left[1 - \frac{\Sigma pq}{\sigma^2}\right]$

Where, R_w = The reliability coefficient of the whole test

n - The number of items in the test

σ -Standard deviation of the test score

p-the proportion of the answering test item correctly

q = (1 - p)

Note 1: If the values of p for each test is equal then Σpq = npq

2: If the values of p for 'n' tests are $p_1, p_2 \ldots\ldots$ pn, then $\Sigma pq = p_1q_1 + p_2q_2 + \ldots\ldots\ldots\ldots\ldots\ldots + p_nq_n$

Example

In a test there are 60 questions. The proportion of answering each question correctly is 70%, if the standard deviation is 10 what is the reliability coefficient?

Solution

Number of questions (n) = 60,

Proportion of correct answers (p) = 0.7 q = 1 - p = 1 - 0.7 = 0.3

Σ pq = npq

S.D. (s) = 10, therefore, the reliability coefficient is given by

$KR_1 = R_w = \frac{n}{n-1}\left[1 - \frac{\Sigma pq}{\sigma^2}\right]$

$KR_1 = \frac{60}{60-1}\left[1 - \frac{60 \times 0.7 \times 0.3}{10 * 10}\right]$

Hence reliability coefficient is 88.88%

Validity

Introduction

A scale possesses validity when it actually measures what it claims to measure. In other words, a scale is said to be valid if it measures what is expected to measure.

Interpretation of test scores ultimately involves predictions about a subject's behavior in a specified situation. If a test is an accurate predictor, it is said to have good validity.

Types of validity:

1. **Content Validity**

Content validity is the representativeness or adequacy of the unit selected of the content such as the substances, the matter, the topic of the measuring instrument etc. Content Validity is also known as logical validity. A test has content validity if the sample of items in the test is representative of all the relevant items that might have been used.

Let, U be the universe of the item; S is the subset of U i.e., $S \subset U$ and x be the item such that x is the element in U then it must be an element of S, i.e., $x \in U \Rightarrow x \in S$

The standardized achievement test is used for the content validity measure.

Content validity is related to face validity, although content validity requires more rigorous statistical tests than face validity, which only requires an intuitive judgment. Content validity is most often addressed in academic and vocational testing, where test items need to reflect the knowledge actually required for a given topic area or job skill. In clinical settings, content validity refers to the correspondence between test items and the symptom content of a syndrome.

2. **Criterion-related Validity**

A common approach, called criterion related validity is to correlate measures with a criterion measure known to be valid. For example, an art-aptitude test has predictive validity if high scores are achieved by those who later do well in art school. The concurrent validity of a new intelligence test may be demonstrated if its scores correlate closely with those of an already well-established test.

The criterion related validity is based on the four decisive factors: (i) An external criterion (ii) regular and future behavior (iii) Logical analysis and (iv)Empirical method.

• It is used to predict the criterion on the basis of some measure.

• It reflects the success of measures for empirical estimating process

In this type of validity, the proposed criterion must possess the following quality:

- Freedom from bias (criterion should be given each subject/matter an equal opportunity to score)

- Reliable (criterion should be stable and reproducible)

- Relevance (criterion should be defined in terms of proper measure). Availability (information specified by the criterion must be available)

The Criterion- related Validity broadly classified as: (a) Predictive validity and (b) Concurrent Validity

(a) Predictive validity:

It refers to the usefulness of the test in prediction some future performances on the criterion. It is concerned with how well the scale can forecast a future criterion. When the criterion measure is collected later the goal is to establish it is called the predictive validity.

(b) Concurrent Validity:

It is concerned with the performances that how it can describe a present criterion. Concurrent Validity is demonstrated where a test correlates well with a measure that has previously been validated. For example, if a test measuring job satisfaction gives similar results to those gathered using a job satisfaction which has been validated in past investigations the new measurement has concurrent validity.

The validity coefficient is measured in terms of the correlation coefficient (r) of the scores of the different tests. We say, for $0.9 \leq r \leq 1$ there is very high validity; for $0.8 \leq r \leq 0.9$ a high validity; for $0.6 \leq r \leq 0.8$ a satisfactory validity: for $0.4 \leq r \leq 0.6$ a moderate validity; for $0.0 \leq r \leq 0.4$ a poor validity; and for $r < 0.0$ a negative validity

C. Construct Validity

It is the validity, which is most complex and abstract because of the complexity of the social parameter. It is based on psychological trait and quality. Construct validity is generally determined by investigating what psychological traits or qualities a test measures; that is, by demonstrating that certain patterns of human behavior account to some degree for performance on the test.

Construct validity can be evaluated by statistical methods that show whether or not a common factor can be shown to exist underlying several measurements using different observable indicators. For determining construct validity, we associate a set of other proposition with the result received from the use of our measuring instrument. If measurements on our devised scale correlated (associated) in a predicted way with the other propositions, we can conclude that there is construct validity.

Scaling

Scores and Scales

Scores

The number of points somebody gets for correct answers in a test is said to be scores. In other words the value of parameter in the observed phenomenon is termed as score. From an experiment or from a test what we obtained as the observation is called the raw score. The raw score is the simple numerical count of responses such as the number of correct answers on an intelligence test. The usefulness of the raw score is limited however, because it does not convey how well someone does in comparison with others taking the same test. Suppose, one attempts to answer 20 IQs having 1 point each and answered 16 correctly then the raw score is 16.

Scale

Scale is a predefined sequence of scores in ascending values that can map an item to it. Scale is a set of all the different levels of symbols or numerals or something so constructed, from the lowest to highest, that these can be assigned by rule to objects or to items or to the individuals or to their behavior to whom it is applied. In general concept, scale is also known as a quantifying appliance used to indicate the systematized numerals of the measuring instrument.

Scaling of the Scores

From a set of scores of the test we can construct a sequence of levels of the values that can be used as an extent for the test of that phenomena, this method of leveling is said to be scaling. For the purpose of scaling it is always desired to make the scores in an array. After that the scores are converted to the percentile points and then to a scale of required form.

The raw scores obtained in test can be converted to different auxiliary scores in relation to the distribution of the raw scores or according to the distribution of parent population. Such scores which are modified/improved/developed from the raw scores are called derived scores. From the derived scores of the same form in sequence can be used to create a continuous structure of the numerals which is the scale required to be constructed.

There are different types of derived scores widely used in the measurement of the phenomenon or the attitudes. The percentile scores, s-score (z-score) and T-score are such derived scores and are used to compare the strength and credibility of the measures. From these scores we can construct the standard scales namely percentile scale, sigma scale (z-scale) and T scale, respectively by arranging the scores lowest to highest.

Difficulties in scaling

In social phenomenon, following are the reasons that create difficulties of scaling in social sciences.

- Abstractness (nonfigurative) of the social phenomena
- Heterogeneity of the social values, customs and norms.
- Changing nature of human behavior Absence of universal measuring of social values
- Laboratory method cannot be applied in social phenomena.

Scales used in Social and Physical sciences

The main scales used in the measure of social/physical characteristics are:

(i) Point scale
(ii) Social distance scale
(iii) Rating scale
(iv) Ranking scale
(v) Thurstone scale

(i) Point scale

In this type of scale words or situations representing the criteria are selected and one point (marks or number) is given for each criteria. Attitude of a person can determined by the use of all the three following method effectively.

Method 1: The respondent is asked to tick one that is representing or favorable to him /her. The scores are counted and result is derived**.**

Method 2: In the second method the respondent is asked to cross the one point or situation which is not favorable to him /her. A point is given to each and every word that has not been crossed. The attitude of the respondent is then determined by counting no of points.

Method 3: In the third method of point scale the respondent is asked to cross, on which points he /she is agree or not.

(ii) Social distance scale

The social distance scale is developed by Emary S. Borgadus to measure the social distances (it is commonly known as Borgadus scale). The social distance may be defined as the proximity and favoritism; for example the cultural distance from one race to the other, custom from one ethnic group to the other etc. To measure a person's (respondent's) attitude how far from the given cause situation the Borgadus scale can be used. Borgadus developed a scale to measure the nearness of liking between two social groups using several items or statements which show the varying relationship of social distance of Americans with other races as English, Korean, Swedish and poles.

(iii) ***Rating scale***

When the character to be measured is not dichotomous in this case the rating scale is used. Rating scale consists of a set of figures that can match to the individual or items to be measured. The response or the opinions of the respondent's attitude is rated in three to six points in continuum (range). The intensity of the attitude is measured by using equal or unequal type intervals. An example of three point rating scale is:

Very good ....satisfactory......................poor

A five points rating scale is

Strongly-Agree.........Agree ....Not-Decided. ......Dis-agree........Strongly-Disagree

(iv) ***Ranking scale***

The ranking scale is similar to rating scale applied to a set of objects or individuals with the preference or liking. In this scale the situations are placed in such a way that, everybody who inspects it knows that one likes the one better than the other. Ranking scales is determined in comparison to a few cases known as stimuli. The item obtaining first preference scores 1, the second as 2, third as 3 and so on. 'The smaller the score the greater the preferences' is the principle of ranking scale.

(v) ***Thurstone scale***

American psychologist Louis L. Thurstone proposed that intelligence was not one general factor but a small set of independent factors of equal importance. He called these factors primary mental abilities. To identify these abilities, he developed a plan to conduct study amongst 250 college students, identified factors and developed a scale of measuring aptitude using factor analysis. The scale so developed is known as Thurstone scale. In educational and psychological experiments, it is used as a main type of scale used to measure the attitude. The statements are collected and arranged in continuum from most favorable to least favorable with neutral point (zero). It is one type of point scale having neutrality point at the central location.

Most- Favored..................neutral ....Least— Favored

Sampling

Introduction

Sampling is an essential part of any research investigation. Almost all research studies involve sampling. It is, therefore, essential that we understand the main concepts of sampling and are familiar with the sampling methods.

Research studies assume that the people selected for studies are representative of a large group about whom generalizations are to be made. We normally cannot survey everyone in the population; but through sampling techniques, we can be confident that only a small part of the total population can fairly represent the total population. Sampling, then, is a technique that saves the time and trouble of questioning 100 percent of the population.

What is Sample?

A sample is a collection of items or elements from a population or universe. Hence, a sample is only a portion or subset of the universe or population. It comprises some observations selected from the population. For instance, if 50 students are drawn from a population of 500 students of a college, these 50 students form the sample for the study.

Population or universe refers to the entire group of people, events, or things of interest that the researcher wishes to investigate. For example, if you are interested in investigating the smoking habits of employees in a chemical factory, then all employees in that factory will form the population.

Sometimes, the entire population will be sufficiently small, and you can include the entire population in your study. If the total items are studied, that is called a census study. However, it is not always possible to study every items or elements in a universe. Usually, the population is too large. Hence, a small, but carefully chosen sample can be used to represent the population. The sample thus selected reflects the characteristics of the population from which it is drawn. For thesis or project work to be undertaken by us, the study of the total population is neither possible nor necessary. Making a census study of the entire universes is not possible on account of limitations of time and money. Hence, sampling becomes inevitable.

Population may be finite or infinite. A finite population is one containing a fixed number of elements. An infinite population is one without limits of any kind and is therefore indeterminate.

Sample Design and Related Terminologies

Sampling design or strategy is the way in which you design your sample plan and select your samples from the population. In designing a sample, you must consider three things: sampling frame, selection of sampling items, and sample size. These terminologies can be explained as follows.

■ Sampling frame is the list identifying each unit in the study population. All the elements in a sampling population constitute its sampling frame. Thus, it may be all the students at university Campus, Kirtipur, all names in the telephone directory, or all persons having their bank accounts with the Nepal Bank Limited. After determining the sampling frame, the researcher will decide how sample will be selected.

■ *Sampling item or unit* is an element (person, institution, etc) of your study that becomes

the basis for selecting your sample.

■ The *size of the sample* must be determined. What should be the sample size? Should fifty or eighty employees be interviewed? Though accuracy is greater with large samples, so are costs.

■ *Sample statistics* are the information obtained from the respondents selected for your study. Your sample statistics become the basis of estimating the prevalence of the characteristics in the study population.

■ *Population parameters* or population mean are the characteristics of the population estimated from the sample statistics. If you measure the entire population and calculate a value like a mean or average, this is called a population parameter.

Thus, the basic components of a sample design are: (a) choosing the sample units (who are to be surveyed), (b) choosing the sample size (how many to be surveyed), (c) choosing the sampling procedure (how to ensure that those who are to be interviewed are included in the sample), and (d) choosing the media (how to reach respondents in the sample? - through mail survey, personal interview, or telephone interview).

THE PRINCIPAL STEPS IN A SAMPLE SURVEY

The main steps involved in the planning and execution of a sample survey may be grouped somewhat arbitrarily under the following heads.

1. **Objectives of the Survey**.
   The first step is to define in clear and concrete terms, the objectives of the survey. It is generally found that even the sponsoring agency is not quite clear in mind as to what it wants and how it is going to use the results. The sponsors of the survey should take care that these objectives are commensurate with the available resources in terms of money, manpower and the time limit required for the availability of the results of the survey.
2. **Defining the Population to be sampled**. The population, i.e., the aggregate of objects (animate or in-animate) from which sample is chosen should be defined in clear and unambiguous terms. For example, in sampling of farms clear-cut rules must be framed to define a farm regarding shape, size., etc., keeping in mind the border-line cases so as to enable the investigator to decide in the field without much hesitation whether or not to include a given farm in the population.

3. **The Frame and Sampling Units**.

The population must be capable of division into what are called sampling units for purposes of sample selection. The sampling units must cover the entire population and they must be distinct, unambiguous and non-overlapping in the sense that every element of the population belongs to one and only one sampling unit. For example, in socio-economic survey for selecting people in a town, the sampling unit might be an individual person, a family, a household or a block in a locality. In order to cover the population decided upon, there should be some list, map or other acceptable material, called the frame, which serves as a guide to the population to be covered. Only good experience person helps to construct a good frame.

4. Data to be collected.

The data should be collected keeping in view the objectives of the survey. The tendency should not be to collect too many data some of which are never subsequently examined and analyzed. A practical method is to chalk out an outline of the tables that the survey should produce. This would help in eliminating the collection of irrelevant information and ensure that no essential data are omitted.

5. The Questionnaire or Schedule. Having decided about the type of the data to be collected, the next important part of the sample survey is the construction of the questionnaire (to be filled in by the respondent) or schedule of enquiry (to be completed by the interviewer) which requires skill, special technique as well as familiarity with the subject-matter under study. The questions should be clear, brief, non-offending, courteous in tone, unambiguous and to the point so that not much scope of guessing is left on the part of the respondent or interviewer. Suitable and detailed instructions for filling up the questionnaire or schedule should also be prepared.

6. Method of collecting information

The two methods commonly employed for collecting data for human populations are : (i) Interview Method. In this method, the investigator goes from house to house and interviews the individuals personally. He asks the questions one by one and fills up the schedule on the basis of the information supplied by the individuals. (ii) Mailed Questionnaire Method. In this method, the questionnaire is mailed to the individuals who are required to fill it up and returns it duly completed. Whether the data should be collected by interview method or mail questionnaire method or by physical observation has to be decided keeping in view the costs involved and the accuracy aimed at. Although mail surveys are less costly, there is scope for considerable non-response. Moreover mail method is practicable only among the educated people who are really interested in the particular survey being conducted. On the other hand, interview method costs more and there are interviewer errors also but without investigators the data collected may be worthless.

7. Non-respondents.

Quite often (due to practical difficulties), the data cannot be collected for all the sampled units. For example, the selected respondent may not be available at his place when the investigator goes there or he may fail or even refuse to give certain information when contacted. This incompleteness, called non-response, obviously tends to change the results. Such cases of non-response should be handled with caution in order to draw unbiased and valid conclusions. Procedures will have to be devised to deal with those who do not furnish information. The reasons for non-response should be recorded by the investigator.

8. Selection of Proper Sampling Design.

The size of the sample (n), the procedure of selection and the estimation of the population parameters along with their margins of uncertainty are some of the important statistical problems that should receive the most careful attention. A number of designs (plans) for the selection of a sample are available and a judicious selection will guarantee good and reliable estimates. For each sampling plan, rough estimates of sample size n can be obtained for a desired degree of precision. The relative costs and time involved should also be considered before making a final selection of the sampling plan.

9. Organization of Field Work. It is absolutely essential that the personnel should be thoroughly trained in locating the sample units, recording the measurements, the methods of collection of required data before starting the field work. The success of a survey to a great extent depends upon the reliable field work. It is very necessary to make provisions for adequate supervisory staff for inspection after field work. From practical point of view a small pretest, (i.e., trying out the questionnaire and field methods on a small scale) has been found to be immensely useful. It always helps to decide upon effective method of asking questions and results in the improvement of the questionnaire. Moreover, it might disclose certain problems and troubles that will otherwise be quite serious on a large-scale survey such as "the cost and the time may far exceed the available money and stipulated period."

10 Summary and Analysis of the Data. The analysis of the data may be broadly classified into the following heads:

a) Scrutiny and editing of the data: An initial quality check should be carried out.by the supervisory staffs while the investigators are in the field. Accordingly, the schedule should be thoroughly scrutinized to examine the plausibility and consistency of the data obtained.

(b) Tabulation of data: Before carrying out the tabulation of the data, we must decide about the procedure for tabulation of the data which are incomplete due to non-response to certain items in the questionnaire and where certain questions are deleted in editing process. The method of tabulation, viz., hand tabulation or machine tabulation, will depend upon the quantity of the data. For large-scale survey, machine tabulation will obviously be much quicker and economical. For a large-scale sample survey, the use of code numbers for qualitative variables is essential for machine tabulation. With simple questionnaire, the answers can sometimes be pre-coded, i.e., entered in a manner in which they can be conveniently or routinely transferred to mechanical equipment such as personal computers, etc. Finally, the tables that lead to the estimates are prepared.

(c) Statistical analysis. After the data has been properly scrutinized, edited and tabulated, a very careful statistical analysis is to be made. Different methods of estimation may be available for the same data. Appropriate formulae should then be used to provide final estimates of the required information. Efforts should be made to keep the procedure free from errors.

(d) Reporting and conclusions. Finally, a report incorporating detailed statement of the different stages of the survey should be prepared. In the presentation of the results, it is good practice to report the technical aspect of the design, viz., the types of the estimators used along with the amount of error to be expected in the most important estimate.

11. Information gained for Future Surveys. Any completed survey is helpful in providing a note of caution and taking lessons from it for designing future surveys. The information gained from any completed sample in the form of the data regarding the means, standard deviations and the nature of the variability of the principal measurements tougher with the cost involved in obtaining the data serves as a potential guide for improved together sampling.

PARAMETER AND STATISTIC

In order to avoid verbal confusion with the statistical constants of the population, viz., mean, variance, etc., of the population which are usually referred to as parameters, statistical measures computed from the sample observations alone, e.g., mean, variance, etc., of the sample have been termed as statistic.

In practice parameter values are not known and their estimates based on the sample values are generally used. Thus statistic which may be regarded as an estimate of the parameter, obtained from the sample, is a function of the sample values only. It may be pointed out that a statistic, as it is based on sample values and as there are multiple choices of the samples that can be drawn from a population, varies from sample to sample. The determination or the characterization of the variation (in the values of the statistic obtains from different samples) that may be attributed to chance or fluctuations of sampling is one of the fundamental problems of the sampling theory.

Sampling Distribution

The number of possible samples of size n that can be drawn from a finite population of size N is NCn. (If N is large or infinite, then we can draw a large number of such samples.) For each of these samples we can compute a statistic, say 't' ....e.g., mean, variance, etc., which will obviously vary from sample to sample. The aggregate of the various values of the statistic under consideration so obtained (one from each sample), may be grouped into a frequency distribution which is known as the sampling distribution of the statistic. Thus, we can have the sampling distribution of the sample mean $\bar{x}$, the sample variance, etc.

Standard Error.

The standard deviation of the sampling distribution of a statistic is known as its Standard Error. The standard errors (S.E.) of some of the well-known statistics are given in Table, where n is the sample size, σ^2 the population variance, P the population proportion and Q = 1- P.

SAMPLING AND NON-SAMPLING ERRORS

The errors involved in the collection, processing and analysis of a data may be broadly classified under the following two heads:

(i) Sampling Errors **(ii) Non-sampling Errors**.

(i) Sampling Errors.

Sampling errors have their origin in sampling and arise due to the fact that only a part of the population (i.e., sample) has been used to estimate population parameters and draw inferences about the population. As such the sampling errors are absent in a complete enumeration survey. Sampling biases are primarily due to the following reasons:

1. Faulty selection of the sample. Some of the bias is introduced by the use of defective sampling technique for the selection of a sample, e.g., purposive or judgment sampling in which the investigator deliberately selects a representative sample to obtain certain results. This bias can select a representative sample to obtain certain results. This bias can be overcome by strictly adhering to a simple random sample or by selecting a sample at random subject to restrictions which while improving the accuracy are of such nature that they do not introduce bias in the results.

2. Substitution.

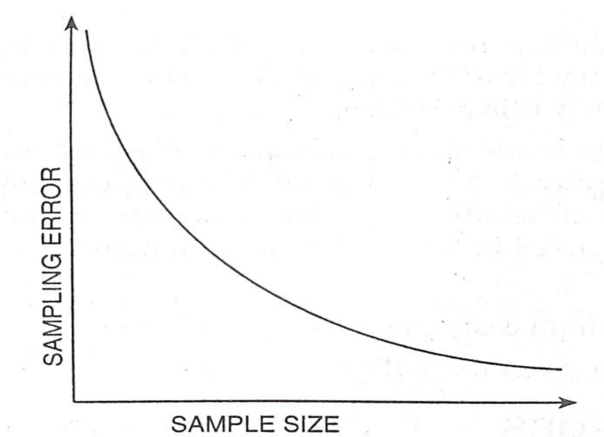
If difficulties arise in enumerating a particular sampling unit included in the random sample, the investigators usually substitute a convenient member of the population. This obviously leads to some bias since the characteristics processed by the substituted unit will usually be different from those possessed by the unit originally included in the sample.

3. Faulty demarcation of sampling units.

Bias due to defective demarcation of sampling units is particularly significant in area surveys such as agricultural experiments in the field or crop cutting survey, etc. In such surveys, while dealing with border line cases, it depends more or less on the discretion of the investigator whether to include them in the sample or not,

4. Constant error due to improper choice of the statistic for estimating the population Parameters.

For example, if $x_1, x_2, \ldots\ldots\ldots, x_n$ is a sample of independent observations, then the sample variance $s^2 = \sum_{i=1}^{n} (x_i - \overline{x})^2 / n$ as an estimate of the population variance σ^2 is biased whereas the statistic $\frac{1}{n} \sum_{i=1}^{n} (x - \bar{x})^2$, is an unbiased estimate of σ^2.



Remark: Increase in the sample size (i.e., the number of units in the sample) usually results in the decrease in sampling error.

. **(ii) Non-sampling Errors**. As distinct from sampling errors which are due to the inductive process of inferring about the population on the basis of a sample, the non-sampling errors primarily arise at the stages of observation, ascertainment and processing of the data and are thus present in both the complete enumeration survey and the sample survey. Thus, *the data obtained in a complete census, although free from sampling errors, would still be subject to non-sampling errors whereas data obtained in a sample survey should be subject to both sampling and non-sampling errors.*

Non-sampling errors can occur at every stage of the planning or execution of census or sample survey. The preparation of an exhaustive list of all the sources of non-sampling errors is a very difficult task. However, a careful examination of the major phases of a survey (complete or sample) indicates that some of the more important non-sampling errors arise from the following factors.

1. The planning of a survey consists in explicitly stating the objectives of the survey. These objectives are then translated into (i) a set of definitions of the characteristics for which data are to be collected, and (ii) into a set of specifications for collecting, processing and publishing. Here the non-sampling errors can be due to:

(a) Data specification being inadequate and inconsistent with respect to the objectives of the survey.

(b) Error due to location of the units and actual measurement of the characteristics, errors in recording the measurements, errors due to ill-designed questionnaire, etc.

(c) Lack of trained and qualified investigators and lack of adequate supervisory staff.

2. Response Errors

These errors are introduced as a result of the responses furnished by the respondents and may be due to any of the following reasons:

(i) Response errors may be accidental

For example, the respondent may misunderstand a particular question and accordingly furnish improper information un-intentionally.

(ii) Prestige bias

An appeal to the pride or prestige of person interviewed may introduce yet another kind of bias, called prestige bias by virtue of which he may upgrade his education, intelligence quotient, occupation, income, etc., or downgrade his age, thus resulting in wrong answers.

(iii) Self-interest

Quite often, in order to safeguard one's self-interest, one may give incorrect information, e.g., a person may give an underestimate of his salary or production and an over-statement of his expenses or requirements, etc.

(iv) Bias due to interviewer

Sometimes the interviewer may affect the accuracy of the response by the way he asks questions or records them. The information obtained on suggestions from the interviewer is very likely to be influenced by interviewer's beliefs and prejudices.

(v) Failure of respondent's memory

One source of error which is common to most of the methods of collecting information is that of 'recall'. Many of the questions in surveys refer to happenings or conditions in the past and there is a problem both of remembering the event and associating it with the correct time period.

3. Non-response Biases.

Non-response biases occur if full information is not obtained on all the sampling units. In house-to-house survey, non-response usually results if the respondent is not found at home even after repeated calls, or if he/she is unable to furnish the information on all the questions or if he/she refuses to answer certain questions. Therefore, some bias is introduced as a consequence of the exclusion of a section of the population with certain peculiar characteristics, due to non-response.

4. Errors in Coverage.

If the objectives of the survey are not precisely stated in clear cut terms, this may result in

(i) the inclusion in the survey of certain units which are not to be included, or

(ii) The exclusion of certain units which were to be included in the survey under the objectives. For example, in a census to determine the number of individuals in the age group, say, 20 years to 50 years, more or less serious errors may occur in deciding whom to enumerate unless particular community or area is not specified and also the time at which the age is to be specified.

5. Compiling Errors.

Various operations of data processing such as editing and coding of the responses, tabulation and summarizing the original observations made in the survey are a potential source of error. Compilation errors are subject to control though verification, consistency check, etc.

6. Publication Errors.

Publication errors, i.e., the errors committed during presentation and printings of tabulated results are basically due to two sources. The first refers to the mechanics of publication—the proofing error and the like. The other, which is of more serious nature, lies in the failure of the survey organization to point out the limitations of the statistics.

Sample Size

The size of the sample is an important factor. It has direct bearing on the accuracy, estimation, cost and administration of the survey. Large sample has low sampling error where as small sample have higher sampling error. To avoid unnecessary cost small sample should be selected. Hence optimum sample size should be selected to fulfill the requirement of efficiency, representativeness, reliability and flexibility. Some of the factors affecting the sample size are nature of study, nature of reaction of respondent towards the subject under study, nature of population i.e. composition of population under study, number of classes in the population, types of sampling used during study etc.

Factors affecting Sample Size

Size of sample depends upon different factors. These are

i. Nature of population
ii. Number of classes
iii. Nature of the study
iv. Types of sampling used
v. Degree of accuracy

Nature of population

If the population under study is homogeneous then small sample size is sufficient, but in case of heterogeneous population large sample size is required to make sample size representative of the population.

Number of classes

For the classification with large number of classes, large sample size is required.

Nature of study

If the study takes long time then small sample size is better from the financial and analysis point of view.

Types of sampling used

The sample size depends upon the type of sampling used. For simple random sampling large sample size is required but for the case of stratified sampling small sample size is sufficient.

Degree of accuracy

If the greater degree of accuracy is required then large sample should be selected.

Testing Reliability of the Sample

If the selected sample is representative of the population then sample is called reliable. The selected sample is reliable or not can be tested using following methods;

i. Drawing parallel sample.
ii. Comparing sample with population.
iii. Drawing sub sample from main sample.

Drawing parallel sample

Draw sample parallel to the drawn sample from the population and compare various measures such as average, dispersion, skewness, kurtosis etc. between the samples. If the comparison measures are alike then the sample is reliable otherwise unreliable.

Comparing sample with population

Different measures computed from samples are compared with that of population. If the measures are identical then the selected sample is reliable.

Drawing sub sample from main sample

The different measures computed from sub sample arc compared with main sample. It cannot be used to find the sample is representative of population or nut but can be used to find if any error occurred due to faulty selection of sample.

Method of Estimating Sample Size

Estimation of sample size by using mean

Let $\bar{x}$ be the sample mean from a random sample of size n drawn from population with mean E($\bar{x}$) and standard deviation σ.

Now,

$$Z = \frac{\bar{x} - E(\overline{x})}{SE(\overline{x})} = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}}$$

at α level of significance and $(1-\alpha)$ confidence limit is

$$P\left(\left|\frac{\bar{x}-\mu}{\frac{\sigma}{\sqrt{n}}}\right| \leq Z\alpha_{/2}\right) = 1- \alpha$$

$P(|\bar{x} - \mu| \leq {}^{\sigma}/_{\sqrt{n}})\ Z_{(}\alpha/2) = 1 - \alpha$

Now, x - μ = d (margin of error) then

$d = \frac{\sigma}{\sqrt{n}} Z\,\alpha/2$

$\sqrt{n} = \frac{\sigma}{d} Z\alpha/2$

$n = \frac{\sigma^2\ {Z_{\alpha/2}}^2}{d^2}$

In case of σ is not known take $\sigma = s$

For the finite population of Size N, sample size = $\frac{\sigma^2\ {Z_{\alpha_2}}^2}{d^2 + \frac{\sigma^2\ {Z_{\alpha_2}}^2}{N}} = \frac{n}{1+\frac{n}{N}}$

Estimation of sample size by using proportion

Let p be sample proportion from random sample of size n drawn from population with proportion P

Now,

$Z = \frac{p - E(p)}{SE(p)} = \frac{p-P}{\sqrt{\frac{PQ}{n}}}$

At α level of significance (1 - α) confidence limit is

$P\left(\left|\frac{p-P}{\sqrt{\frac{PQ}{n}}}\right| \leq Z\alpha/_2\right) = 1 - \alpha$

or $P\ (|p - P| \leq \sqrt{\frac{PQ}{n}}\ Z\alpha/_2 = 1 - \alpha$

Now, p - P = d (margin of error) then

$d = \sqrt{\frac{PQ}{n}}\ Z\alpha/_2$

$\sqrt{n} = \frac{Z_{\alpha/2}\sqrt{PQ}}{d}$

n= $\frac{PQ\ Z_{\alpha/2}{}^2}{d^2}$

In case of P is not known take P = p.

For the finite population of size N, sample size =$\frac{PQ\ Z_{\alpha/2}{}^2}{d^2+\frac{PQ\ Z_{\alpha/2}{}^2}{N}}$ = $\frac{n}{1+\frac{n}{N}}$

Example 1

Determine the minimum sample size required so that the sample estimate lies within 10% of the true value with 95% level of confidence when coefficient of variation is 60%.

Solution

Here,

C.V. = 60% = 0.6

P ($|\bar{x} - \mu| \leq 0.1\ \mu$) = 0.95

(i) Confidence level (1 - α) = 95% = 0.95 then α = 0.05

Now,

P$\left(\left|\frac{\bar{x}-\mu}{\frac{\sigma}{\sqrt{n}}}\right| \leq Z_{\alpha/2}\right)$ = 1- α

P($|\bar{x} - \mu| \leq \sigma/\sqrt{n}$) Z$_($$\alpha/2$) = 0.95

P($|\bar{x} - \mu| \leq 1.96 \times \frac{\sigma}{\sqrt{n}}$) =0.95

From equation (i) and (ii)

0.1μ = 1.96 × $\frac{\sigma}{\sqrt{n}}$

$\sqrt{n} = \frac{1.96}{0.1} \times \frac{\sigma}{\sqrt{n}}$

n= $\left(\frac{1.96}{0.1} \times \frac{\sigma}{\sqrt{n}}\right)^2$

n = 384.16 × CV^2

n = 384.16 × $(0.6)^2$

or n = 138.29 = 138

Hence required sample size is 138.

Example 2 In measuring reactions time, a psychologist estimates that the standard deviation is 0.05 seconds. How large a sample of measurement must be taken in order to be 99% confident that the error of his estimate will not exceed 0.01 seconds?

Solution

Here,

Sample size (n) = ?

Standard deviation (s) = 0.05

Confidence interval (1 - α) = 99% = 0.99

or α = 0.01 $Z_{\alpha/2}$= 2.58

Error (d) = 0.01

Here σ = s

n = $\frac{\sigma^2 \; {Z_{\alpha_2}}^2}{d^2} = \frac{(0.05)^2(1.96)^2}{(0.01)^2}$ = 166.4 ≈ 167

Hence required sample size is 167.

Example 3

A researcher wants to conduct a survey of disabled at Kathmandu valley. What should be the sample size of the prior estimate of population of disables if the population is 10% and the desired error of estimation is 2% and level of significance is 5%.

Solution

Sample size (n) = ?

Population proportion (p) = 10% = 0.1

q = 1 - p = 0.9

Error (d) = 2% = 0.02

Level of significance (α) = 5%

Here P = p

$$n= \frac{PQ\, Z_{\alpha/2}^{\;2}}{d^2} = \frac{(1.96)^2 \times 0.1 \times 0.9}{(0.02)^2} = 864.36 \approx 865$$

Hence required sample size is 865**.**

Example 4

For p 0.2, d = 0.05 and z = 2 find n. Also find n if N = 1000.

Solution

Here P= p

Now

$$n= \frac{PQ\, Z_{\alpha/2}^{\;2}}{d^2} = \frac{4 \times 0.2 \times (1-0.2)}{0.05^2} = 256$$

When N = 1000

$$\text{Sample size} = \frac{n}{1+\frac{n}{N}} = \frac{256}{1+\frac{256}{1000}} = 203.82 \approx 204$$

Example 5

The mean systolic blood pressure of a certain group of people was found to be 125 mm of Hg with standard deviation of 15 mm of Hg. Calculate sample size to verify the result at 5'y level of significance if error do not exceed 2. Also find sample size if sample is selected from population of size 500.

Solution

Standard deviation (s) = 15

Level of significance (α) = 5%

Sample size (n) = ?

Error (d) = 2 Here σ = s

Now,

n = $\frac{\sigma^2 \ Z_{\alpha_2}{}^2}{d^2} = \frac{(15)^2(1.96)^2}{(2)^2}$ =216.09 ≈ 216

When N = 500

Sample size = $\frac{n}{1+\frac{n}{N}} = \frac{216}{1+\frac{216}{500}}$ = 150.83 ≈ 151

YAMANE FORMULA

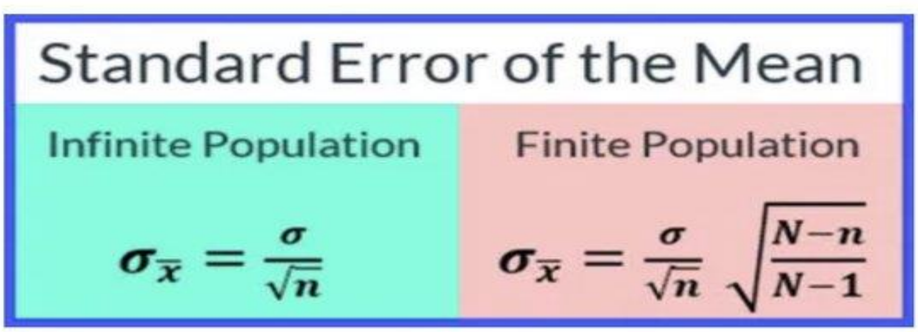
n=$\frac{N}{1+N\times e^2}$

Where n= the sample size

N= the population size

e= the acceptable sampling error

95% confidence level and p= 0.5 are assumed



Working with a finite population and if the population size is known, the **Yamane formula for determining the sample size is given by:**

$n=N/(1+N\ e^2)$

Where

n= corrected sample size, N = population size, and e = Margin of error (MoE), e = 0.05 based on the research condition.

Let's assume that the population is 10,000. At 5% MoE., the sample size would be: $10000/(1+10000(.05^2)$

$=10000/26$

$= 384.61 \sim 385$

In a finite population, when the original sample collected is more than 5% of the population size, the corrected sample size is determined by using the Yamane's formula.

In the example above, 5% of 10,000 is 500 and hence the corrected size is 385 although for research purposes, even 385 is a big number (for handling and collection point of view) and the researcher has to make a decision to collect even smaller number in order of ease of handling, costing but he has to ensure that the sample is representative.

Sampling Frame

The sampling frame (also known as the “sample frame” or “survey frame”) is indeed the actual collection of units. A sample has now been taken from this. A basic random sample gives all units in it an equal probability of being drawn and appearing in the sample.

A complete list or collection from which our sample participants will be drawn in a predetermined manner. The list will be organized in some way. That is, each member of a population will have an individual identity and a contact mechanism. This allows you to categorize and code known information about segmentation features.

Collecting the sample indicates that we have a supply or list of all the individuals of the target population from which to take a sample, as well as a process for selecting the sample. Any resource that has the information needed to reach every individual in the targeted group qualifies as a source.

Characteristics of a Good Sampling Frame

Be assertive when selecting lists! Make sure the sample frame is large enough for our requirements. A decent sample frame for research on living conditions, for example, might include:

Everyone is in the target demographic.

Exclude everyone who isn’t part of the target group.

A file containing factual information that may be used to reach specific people.

Other considerations:

Each member has a unique identification. This might be a short number code (e.g., from 1 to 3000).

Make sure the frame doesn’t have any duplicates.

The list should be well organized. Sort them alphabetically for better access

Information should be up to date. This might need to be examined regularly (e.g., for address or contact number changes).

Examples of the Sampling Frame

The issue is that studying every individual in a population is not always practical or practicable.

Suppose we might be curious to learn about the opinions of Nepalese bankers about vehicle ownership, for example. Gathering data from every bank in the Nepal would be too timeconsuming and expensive. You can investigate a sample of the population in situations like these.

The process of picking a sample should be intentional, and you can utilize various sampling strategies based on the research's aim.

It would help if we first constructed a sampling frame, which would be a list of all the units in the population of interest before we can choose a sample. Our study findings can only benefit the population identified by the sample frame.

Conclusion

A sampling frame is a researcher's list or device to specify the population of interest. A basic random sample gives all units an equal probability of being drawn and appearing in the sample.

People, organizations, and existing records might all be considered units. It is critical to be as detailed as possible when describing the population.

Issues of choosing appropriate sampling technique(s) while selecting samples

Choosing a sampling strategy is an essential step in the capture phase of the data journey and will ensure that, data is reliable and reflects the characteristics of target group. In this blog, we'll take step by step through the process by outlining the ways in which primary data is collected using an example in which a survey on characteristics (tax, education levels, etc) is collected on residents in five towns. The towns are of different sizes and have a total of 3,200 households. These 3,200 households make up the target population for survey.

Step one: Define sample and target population

At times, the survey may require covering the entire target population, as is the case in mapping or population studies. That's usually referred to as a census survey. However, target populations are generally large and expensive to survey. In our example, it may not be feasible to visit all 3,200 households of the five towns. Instead, we want to choose a smaller sample that would be representative of the population and reflect its characteristics.

A survey that is done on a smaller number of the target population is referred to as a sample survey. We can infer our findings for the entire population based on this representative sample.

Step two: Define sample size

The first step in sampling exercise will be decided on an appropriate sample size. There are no strict rules for selecting a sample size. We can make a decision based on the objectives of the project, time available, budget, and the necessary degree of precision.

In order to select the appropriate sample size, we will need to determine the degree of accuracy that we want to achieve. For this, we'll need to establish the confidence interval and confidence level of our sample.

The confidence interval, also called the margin of error, is a plus or minus figure. It is the range within which the likelihood of a response occurs. The most commonly used confidence interval is +/- 5. If we wish to increase the precision level of our data, we would further reduce the error margin or confidence interval to a +/- 2. For example, if our survey question is “does the household pay tax?” and 65% of our sampled households say “yes,” then using a confidence interval of +/- 5, we can state with confidence that if we are asked the question to all 3,200 households, between 60% (i.e. 65-5) and 70% (i.e. 65+5) would have also responded “yes.”

The confidence level tells how sure we want to be and is expressed as a percentage. It represents how often the responses from our selected sample reflect the responses of the total population. Thus, a 95% confidence level means we can be 95% certain. The lower the confidence level, the less certain we will be.

Most surveys use the 95% confidence level and a +/- 5 confidence interval. When we put the confidence level and the confidence interval together, we can say that we are 95% sure that, if we had surveyed all (3,200) households, between 60% and 70% of the households of the target population would have answered “yes,” to the question “does the household pay tax?”.

The size of sample may be determined using any standard sample size calculator. Using a standard sample size calculator (as can be seen in table one below) for our example of 3,200 households in five towns, we can examine the difference in sample sizes based on different confidence levels and intervals.

Option A

If we decide on a 5% confidence interval and want to achieve a 95% confidence level, the sample size will be 345 households.

Option B

If we wish to have higher accuracy and increase the confidence level to 99%, the recommended sample size would be 551.

The quality of our findings are likely to only be marginally better than with option A or B, as the rate of improvement of accuracy gradually diminishes with the increase in sample size. The size of sample should therefore be decided by the objectives of the study and resources available.

Step three: Define sampling technique

Once we’ve chosen the sample size for survey, we need to define which sampling technique to select sample from the target population. The sampling technique that’s right depends on the nature and objectives of project. Sampling techniques can be broadly divided into two types: random sampling and non-random sampling.

Random sampling

As the name suggests, random sampling literally means selection of the sample randomly from a population, without any specific conditions. This may be done by selecting the sample from a list, such as a directory, or physically at the location of the survey. If we want to ensure that a particular household does not get selected more than once, you can remove it from the list. This type of sampling is called simple random sampling without replacement. If you choose not to remove duplicate households from the list, you would do a simple random sampling with replacement.

Systematic sampling is the most commonly used method of random sampling, whereby you divide the total population by the sample size and arrive at a figure which becomes the sampling interval for selection. For example, if you need to choose 20 samples from a total population of 100, your sampling interval would be five. Systematic sampling works best when the population is homogeneous, i.e. most people share the same characteristics. In our example, the sampling interval would be nine (3200/345= 9 for a 95% confidence level and 5% confidence interval). Thus we will select every ninth household in a town.

However, populations are generally mixed and heterogeneous. To ensure sufficient inclusion of all categories of the population, we need to identify the different strata or characteristics and their actual representation (i.e. proportion) in the population. In such cases, we can use the stratified random sampling technique, whereby we first calculate the proportion of each strata within the population and then select the sample in the same proportion, randomly or systematically, from all the strata.

If we take our earlier example of five towns, to calculate a stratified random sample, you will need to calculate the proportion of each town within the sample size of 345 as shown in table two below. Column three gives the proportion of each town of the total population (3,200). In column four, the sample size (345) is proportionately divided across the five towns. For example, town three, which is 25% of the total population, will select 86 households with a sampling interval of nine (i.e. 800/86) in the same manner as was done for systematic sampling.

Table 2: Calculate stratified random sample

Location	Population size	Proportion (%) of population	Stratified sample size
Town 1	1200	38%	129
Town 2	900	28%	97
Town 3	800	25%	86
Town 4	180	6%	19
Town 5	120	4%	13
Total	*3200*		*345*

Non-random sampling

In non-random sampling, the sample selection follows a particular set of conditions and is generally used in studies where the sample needs to be collected based on a specific characteristic of the population. For example, you may need to select only households which own a car, or have children less than six years of age. For this, you would consciously select only the 345 or 551 households that have those characteristics. Also termed purposive or subjective sampling, non-random sampling methods include convenience, judgment, quota and snowball sampling.

Step four: Minimize sampling error

It's normal to make mistakes during sample selection. Our efforts should always be to reduce the sampling error and make the chosen sample as representative of the population as possible. The robustness of sample depends on how we minimize the sampling error. The extents of errors during sampling vary according to the technique or method you choose for sample selection.

For samples selected randomly from a target population, the results are generally prefixed with the +/- sampling error, which is the degree to which the sample differs from the population. If our study requires to know the extent of sampling error that is acceptable for the survey, you can select a random sampling technique. In random sampling, you will be able to regulate the survey design to arrive at an acceptable level of error. In a non-random sample selection, the sampling error remains unknown.

Thus, when your sample survey needs to infer the proportion of a certain characteristics of the target population, you can select a random sampling method. But if you want to know the perceptions of residents regarding taxation laws or the school curriculum, you would want to capture as many perceptions as possible, and therefore select a non-random method in situations where sampling errors or sampling for proportionality are not of concern. Non-random sampling techniques can be very useful in situations when you need to reach a targeted sample with specified characteristics very quickly.

If you don't have a sampling strategy in place, you may collect data which is biased or not representative, rendering your data invalid.

Statistical Analysis

Analysis means the categorizing, ordering, manipulating, and summarizing of data to obtain answers to research questions. The purpose of analysis is to reduce data to intelligible and interpretable form so that the relations of research problems can be studied and tested. A primary purpose of statistics, for example, is to manipulate and summarize numerical data and to compare the obtained results with chance expectations. A researcher hypothesizes that styles of leadership affect group-member participation in certain ways. He plans an experiment, executes the plan, and gathers data from his subjects. Then he must so order, break down, and manipulate the data that he can answer the question: How do styles of leadership affect group-member participation? It should be apparent that this view of analysis means that the categorizing, ordering, and summarizing of data should be planned early in the research. The researcher should lay out analysis paradigms or models even when working on problem and hypotheses.

Data Editing

Editing is the process of examining errors and omissions in the collected data and to make necessary corrections. Data should be edited after getting the filled up questionnaire or schedule and before entering in to the step of data processing. It is done to assure the data are accurate, consistent, uniformly entered, complete and well arranged. Editing is carried out in two stages:

(i) field editing
(ii) central editing

Field editing is the review of reporting forms by enumerator or investigator for completing what the signs and symbols have written in abbreviated form in the time of recording respondents' response. Central editing is editing obvious errors such as entry in wrong place, missing replies etc. by editor when all schedules or forms have been completed and returned to office.

Data Coding

It is process of assigning numerals or other symbols to answers so that response can be put into a limited number of class or categories. The quantitative data collected using questionnaire or schedule is numeric so that no need of coding. For the data which is qualitative in nature the numeric codes are to be used before the analysis. For the statistical treatments qualitative responses are to be converted into numerical figures which satisfy, all the rules of arithmetic operation. Different social scales are used on assigning numerical figures to the qualitative response. For example for male and female code 1 and 0 are used.

Classification of Data

The data contained in questionnaire or schedule will not enable us to see quickly all possible characteristics. In order to make data easily understandable the classification is adopted. Classification is the process of arranging the related facts or data into different groups or classes according to their similarities. Facts differ from class to class with re characteristics which is the basis of classification.

The classification should be

(i) according to research problem
(ii) exhaustive
(iii) mutually exclusive
(iv) independent

The main objectives of classification are

i) to condense mass of data
ii) to facilitate comparison
iii) to pinpoint feature of data at a glance
iv) to enable statistical treatment

Types of classification: Statistical data are classified in respect of their characteristics. Broadly there are four basic types of classification namely

a) Chronological classification
b) Geographical classification
c) Qualitative classification
d) Quantitative classification

a) **Chronological Classification**
In chronological classification the collected data are arranged according to the order of time expressed in years, months, weeks, etc.. The data is generally classified in ascending order of time. For example, the data related with population, sales of a firm, imports and exports of a country are always subjected to chronological classification. For example, The estimates of birth rates in Nepal during 1970 - 76 are

Year	1970	1971	1972	1973	1974	1975	1976
Birth rate	36.8	36.9	36.6	34.6	34.5	35.2	34.2

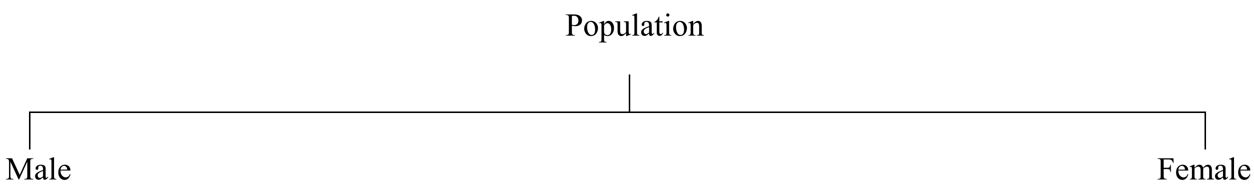
b) **Geographical Classification**

In this type of classification the data are classified according to geographical region or place. For instance, the production of wheat different countries etc.

Country	America	China	Denmark	France	Nepal
Yield of wheat kg/acre	1925	893	225	439	862

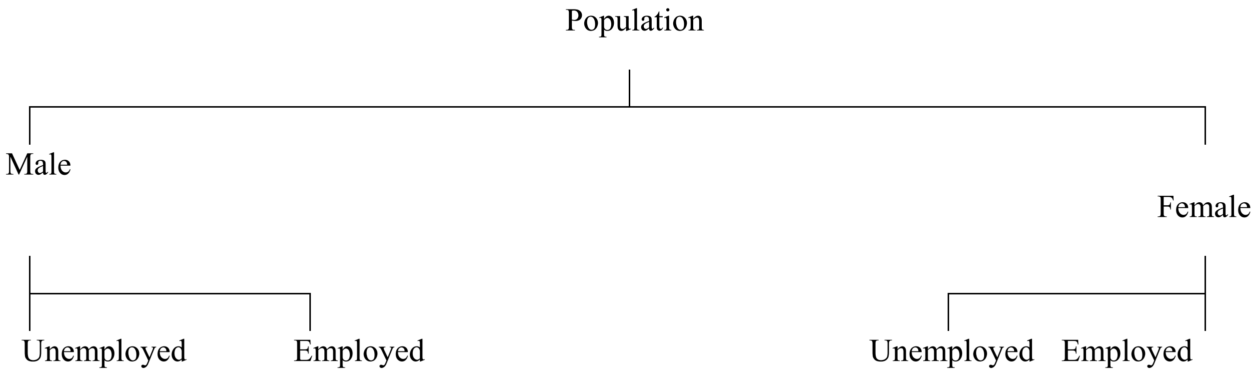
c) **Qualitative Classification:**

In this type of classification data are classified on the basis of some attributes or quality like: sex, literacy, religion, employment etc. Such attributes cannot be measured along with a scale.



(i) The classification, where two or more attributes are considered and several classes are formed, is called a manifold classification. For example, if we classify population simultaneously with respect to two attributes e.g., sex and employment then population are first classified with respect to 'sex' into 'males' and 'females'. Each of these classes may then be further classified into 'employment' and 'unemployment' on the basis of attribute 'employment' and as such population are classified into four classes namely. (i) Male employed (ii) Male unemployed (iii) Female employed ((iv) Female unemployed

Still the classification may be further extended by considering other attributes like marital status etc. This can be explained by the following chart



(d) Quantitative classification

Quantitative classification refers to the classification of data according to some characteristics that can be measured such as height, weight, etc.

Data Entering into Spreadsheet

A spreadsheet is an interactive computer application program for organization and analysis of data in tabular form. Spreadsheets developed as computerized simulations of paper accounting worksheets. The program operates on data represented as cells of an array organized in rows and columns. Each cell of the array is a model-view-controller element that can contain either numeric or text data or the results of formulas that automatically calculate and display a value based on the contents of other cells. The user of the spreadsheet can make changes in any stored value and observe the effects on calculated values. This makes the spreadsheet useful for "what-if" analysis since many cases can be rapidly investigated without tedious manual recalculation. Modern spreadsheet software can have multiple interacting sheets and can display data either as text and numerals or in graphical form.

Management of Missing and Inconsistent Information

Generally, in data management activity of research work a researcher faces the threats of

i) Missing data
ii) Impossible values
iii) Inconsistencies and
iv) Transcription errors.

Missing and inconsistent data (information) are a part of almost all research and all the researcher have to deal with it from time to time. There are various alternative ways of dealing with missing data. To get data with less missing and inconsistent information attention should be given from the designing questionnaire to data entry. Most of the missing are arisen in the survey field because of the imperfection of the field workers and the less skill of the person who involved in data entry work.

There are a number of strategies for handling missing and inconsistent data and common will be described here. These methods can be accomplished with standard statistical software packages (SAS, SPSS).

List wise deletion

In this method, cases with any missing values are deleted from an analysis. This method is sometimes called *complete case analysis* because only cases with complete data are retained. This is the default procedure for many statistical programs but it is generally not an advisable method.

Pairwise deletion

In this method, the maximum amount of available data is retained and so this method is sometimes referred to as *available case analysi*s. Cases are excluded from only operations in missing which data are missing on a variable that is required. In a correlation matrix, for example a case that was data on one variable would not be used to calculate the correlation coefficient between that variable and another but would be included in all other correlations.

Ways of managing Missing and Inconsistent data

The quality of the data can be kept up by careful and systematic method of data cleaning. The following are the steps by using which we can reduce the inconsistent observation and problems of missing data.

- Develop a plan for data management
- Make a an intensive training before data entry
- Make strategy of getting quality data
- Maintain the question that can cross check the responses
- Adopt checking system of impossible values
- Record the variables and if possible create composite variables
- Preferably do not make a change in raw data set, if changed logically it should be documented
- Coding system should be preferably used to reduce such errors
- Use standard methods of data cleaning using software
- Use the method of labeling the values and merge cells if possible
- Once the data set is cleaned, the next step is to format it for analysis
- Data formatting should be done using code
- Maintain a master dataset that is distributed to everyone conducting analyses

Descriptive Statistical measure

Types of average

I. Arithmetic Mean
II. Geometric mean
III. Harmonic mean
IV. Median
V. Mode

Measure of Dispersion

Absolute and relative measure of dispersion

Types of dispersion

Range

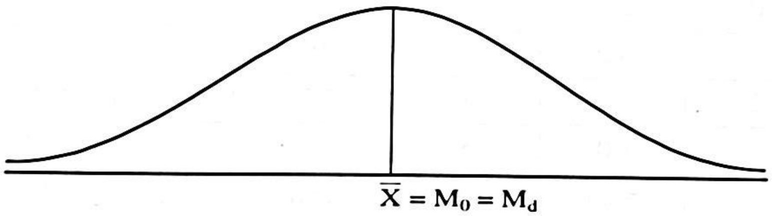
Quartile deviation

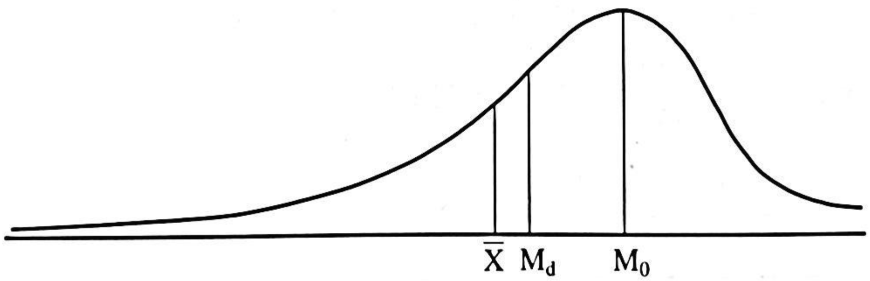
Mean deviation

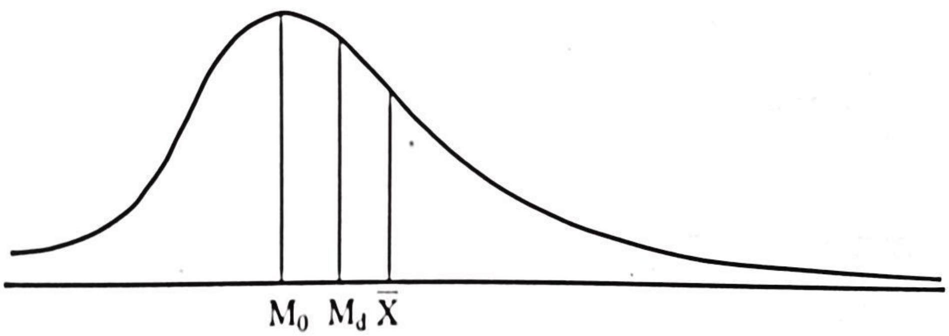
Standard deviation

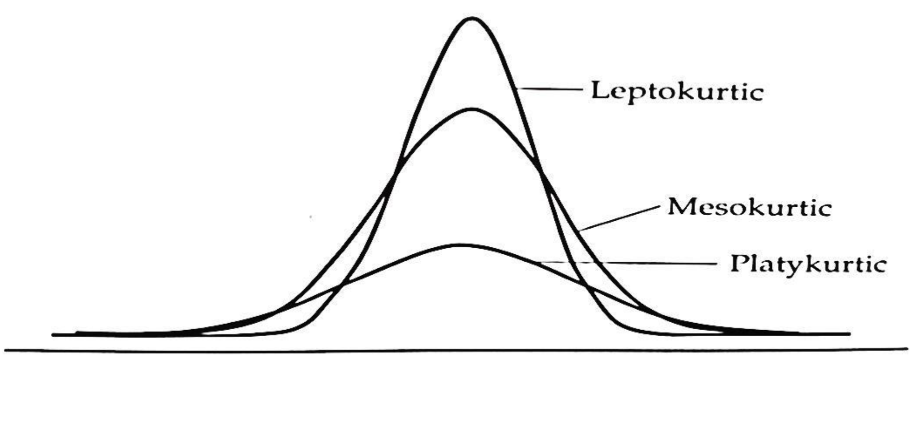
(Coefficient of Variation)

Skewness **kurtosis** $K=\frac{Q_3 - Q_1}{2(P_{90-P_{10}}}$ **K=0.263**









Correlation and Regression

Inferential statistics

Testing of Hypothesis

Z test

It is important parametric test based upon the normality assumption. Traditionally Z test is used, when the samples are selected from population of known parameter with sample size more than 30. We consider that if sample size is more than 30 then sample selected from non normal population is also approximately normal distributed.

Z test is defined as the ratio of difference between t and E(t) to the S.E.(t)

$$Z = \frac{t-E(t)}{SE.(t)} \sim N(0, 1),$$

where t = statistic, E(t) = Expected value of statistic and S.E.(t) = Standard error of the statistic.

Z test is used to test

- Significance of single mean.

- Significance of difference between two means.

- Significance of single proportion.

Significance of difference between two proportions

- Significance of difference between sample correlation and population correlation.

- Significance of difference between independent sample correlations

Test of significance of a single mean

Let us consider sample of size n (n > 30) has been drawn from the normal population N (μ, σ^2) then the sample mean $\bar{x} \sim N \ (\mu, \sigma^2)$.

Different steps in the test are;

Problem to test

Ho:$\mu = \mu_0$ (sample is drawn from population with mean μ_0)

H1: $\mu \neq \mu_0$ (Two tailed test)

or H1: $\mu > \mu_0$ (One tailed right)

or H1: $\mu < \mu_0$ (One tailed left)

Test statistic

For the sample selected from the population of unknown size

$Z = \frac{\bar{X} - E(\bar{X})}{SE.(\bar{X})} \quad = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}}$ for known variance

$\frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}}$ for unknown variance(for large sample size($\hat{\sigma} = s$)

For the sample selected from the population of known size

$Z = \frac{\bar{X} - E(\bar{X})}{SE.(\bar{X})} = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}\sqrt{\frac{N-n}{N-1}}}$ for known variance

$\frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}\sqrt{\frac{N-n}{N-1}}}$ for unknown variance

Where $\bar{X}$ = sample mean, μ = population mean, σ = population s.d. s = sample s.d.,

N = population size, n = sample size

Level of significance

Let α be the level of significance. Usually we take α = 0.05 unless we are given.

Critical value

Critical or tabulated value of Z is obtained from table according to the level of significance and alternative hypothesis.

Decision

Reject Ho at α level of significance if I z I > $Z_{tabulated}$, accept otherwise.

Example

A sample of 400 students is found to have mean height of 170 cm. Can it be reasonably regarded as a sample from a large population with mean height 169.5 cm and standard deviation 3.5 cm?

Solution

Here,

Sample size (n) = 400

Sample mean ($\bar{X}$) = 170

Population mean (μ) = 169.5

Population S.D. (σ) = 3.5

Problem to test

Ho : Mean height of students is 169.5 cm (μ = 169.5)

H_1 = Mean height of student is not 169.5 cm ($\mu \neq$ 169.5) (Two tailed)

Test statistic

$$Z = \frac{\bar{X} - \mu}{\frac{\sigma}{\sqrt{n}}} = \frac{170 - 169.5}{\frac{3.5}{\sqrt{400}}} \quad \frac{0.5 \times 20}{3.5} = 2.857$$

Critical value

Let 5% be the level of significance then critical value is Ztab = $Z\alpha/2$ = 1.96 Decision Here Z= 2.857 > Z_{tab} = 1.96, reject Ho at 5% level of significance.

Conclusion

The sample of 400 students cannot be regarded as sample from large population with mean height 169.5 cm and standard deviation 3.5 cm.

Test of significance difference between two means

Let us consider two independent samples of size n_1 and n_2 be drawn from population having means means μ_1 and μ_2 and variances σ_1^2 and σ_2^2 respectively. Let $\bar{X}_1$ and $\bar{X}_2$ be the sample means.

For large n_1 and n_2.

$\bar{X}_1 \sim N(\mu_1, \frac{\sigma_1^2}{n_1}$

$\bar{X}_2 \sim N(\mu_2, \frac{\sigma_2^2}{n_2}$

$\bar{X}_1$ - $\bar{X}_2$ $\sim$ $N(\mu_1 - \mu_2 , \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2})$

Different steps in the test are

Problem to test

Ho: $\mu_1 = \mu_2$ There is no significant difference between two population mean.

H1: $\mu_1 \neq \mu_2$ (two tailed)

or H1 : $\mu_1 < \mu_2$ (one tailed left)

or H1 : $\mu_1 > \mu_2$ (one tailed right)

Test statistic

$$\boldsymbol{Z} = \frac{\bar{X}_1 - \bar{X}_2 - E(\bar{X}_1 - \bar{X}_2)}{\boldsymbol{S.E.}(\bar{X}_1 - \bar{X}_2)}$$

$$\boldsymbol{Z} = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

When population means and variances are known

$$\boldsymbol{Z} = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

When population variances are known

$$\boldsymbol{Z} = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

When population variances are unknown

for large sample size $\widehat{\sigma_1^2} = S_1^2$ and $\widehat{\sigma_2^2} = S_2^2$

$\bar{X}_1$ = sample mean of size n_1,

$\bar{X}_2$ = sample mean of size n_2

σ_1^2 = population variance of first population

σ_2^2 = population variance of second Population

S_1^2 = sample variance of first sample

S_2^2 = sample variance of second sample.

Level of significance

Let a α be the level of significance. Usually we take α = .05 unless we are given.

Critical value

Critical or tabulated value of Z is obtained from table according to the level of significance and alternative hypothesis.

Decision

Reject Ho at a level of significance if I z I > $_{\text{Ztabulated}}$, accept otherwise.

Example

In a random sample of 500 the mean is found to be 20. In another independent sample of 400 the mean is 15. Could the samples have been drawn from the same population with S.D. 4? Solution Here,

Sample size of first sample (n_1) = 500

Sample mean of first sample ($\bar{X}_1$) = 20

Sample size of second sample (n_2) = 400

Sample mean of second sample ($\bar{X}_2$) = 15

Population S.D. of first (σ_1) = 4

Population S.D. of second (σ_2) = 4

Problem to test

Ho : μ_1 = μ_2 (both the populations are same)

H1: $\mu_1 \neq \mu_2$ (population are different)

Test statistic

$$\boldsymbol{Z} = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

$$\boldsymbol{Z} = \frac{(20-15)}{\sqrt{\frac{16}{500}+\frac{16}{400}}} = \mathbf{18.51}$$

Critical value

Let α = 5 % be the level of significance the critical value is $Z_{tabulated}$ = Z α /2 = 1.96. .

Decision

Z =18.51 > Ztabulated = 1.96, reject Ho at 5% level of significance.

Conclusion

We cannot conclude that the samples have been drawn from the same population.

Test of significance difference between two proportions:

Let P_1 and P_2 be the two population proportions possessing a certain characteristic. Let two independent samples of sizes n_1 and n_2 be drawn from the two population. Also p_1 and p_2 be the proportion of units possessing certain characteristic in the two samples.

For large sample size

$p_1 \sim N(p_1 \;, \frac{P_1 Q_1}{n_1})$

$p_2 \sim N(p_2 \;, \frac{P_2 Q_2}{n_2})$

Then

$p_1 - p_2 \sim (p_1 \;\; - p_2 \,, \frac{P_1 Q_1}{n_1} + \frac{P_2 Q_2}{n_2})$

Different steps in the test are;

Problem to test

$H_0 : P_1 = P_2$

$H_1 : P_1 \neq P_2$ (Two tail test)

$H_1 : P_1 > P_2$ (One tail right)

$H_1: P_1 < P_2$ (One tail left)

Test statistic

$$\boldsymbol{Z} = \frac{(p_1 - p_2) - E((p_1 - p_2)}{\boldsymbol{S.E.}((p_1 - p_2)}$$

$$= \frac{(p_1 - p_2 - (P1 - P2)}{\sqrt{\frac{P_1Q_1}{n_1} + \frac{P_2Q_2}{n_2}}}$$

$$= \frac{(P1 - P2)}{\sqrt{\frac{P_1Q_1}{n_1} + \frac{P_2Q_2}{n_2}}}$$

If population proportion are given

$$= \frac{(p_1 - p_2}{\sqrt{PQ(\frac{1}{n_1} + \frac{1}{n_2})}}$$

If population proportion are not given

Where P_1 = population proportion of first population

P_2 = population proportion of second population

p_1= sample proportion of first sample of size n_1

p_2 = sample proportion of second sample of size n_2

Level of significance

Let α be the level of significance. Usually we take α = .05 unless we are given.

Critical value Critical or tabulated value of Z is obtained from table according to the level of significance and alternative hypothesis.

Decision

Reject Ho at a level of significance if I z I > $Z_{tabulated}$, accept otherwise.

Example

A machine puts out 21 defective articles in a sample of 500 articles. Another machine gives 3 defective articles in a sample of 100 are the two machines significantly different in their performance? Use p value method at 1% level of significance.

Solution

Here Defective articles by a machine (x_1) = 21

Number of articles by a machine (n_1) = 500

Defective articles by another machine (x_2) = 3

Number of articles by another machine (n_2) = 100

Sample proportion of defective article by a machine (p_1) = $\frac{x1}{n1} = \frac{21}{500}$ = 0.042

Sample proportion of defective article by another machine (p_2) = $\frac{x2}{n2} = \frac{3}{100}$ =0.03

Let

P_1 = Population proportion of defective from a machine

P2 = Population proportion of defective from another machine

P = $\frac{n_1p_1+n_2p_2}{n_1+n_2} = \frac{500\times0.042+100\times0.03}{500+100} = \frac{24}{100} = 0.04$

Level of significance (α) = 1%

Problem to test

Ho : $P_1 = P_2$ (There is no significance difference in performance of machines)

H_1 : $P_1 \neq P_2$ (There is significance difference in performance of machines)

Test statistic

$$Z= \frac{(p_1 \; -p_2}{\sqrt{\boldsymbol{PQ}(\frac{\mathbf{1}}{\boldsymbol{n_1}}+\frac{\mathbf{1}}{\boldsymbol{n_2}})}}$$

$$\frac{0,042-0.03}{\sqrt{0.04\times0.96(\frac{1}{500}+\frac{1}{100})}} = 0.571$$

Now prob(Z≥ Zcalculated) $= \text{prob}(Z \geq 0.571) = 0.5 - \text{prob}(0 \leq Z \leq 0.571)$

$$= 0.5 - 0.2175 = 0.284$$

For two tailed test, p value = 2 Prob (Z ≥ $_{\text{Zcalculated}}$) = 2 x 0.284 = 0.568

Here α = 1% = 0.01

Decision P value = 0.568 > α = 0.01, accept H_0 at 1% level of significance.

Conclusion

There is no significant difference in performance of two machines.

t test

When the sample size is small (traditionally it is assumed less than or equal to 30), then the sampling distribution of the sample mean is assumed to follow student's t distribution. The t distribution is also similar to normal distribution having shape as in normal distribution but little bit flatter. As the sample size increases the shape of t distribution is more likely to normal curve. Whatever be the sample size the statistical software uses the t test for all sample size instead of Z test, since it can compute the tail area of the curve (p value) or to compare with the pre-assigned value of a.

t test is based upon the assumption that

• Sample size small

• Sample is selected from normal population.

• Population standard deviation is not known.

• Samples are independent.

It is used to test

• Significance of single mean.

• Significance of difference between means.

• Significance of correlation coefficient.

• Significance of regression coefficient.

Some other test

(i)Chi- square test

ii) ANOVA (Analysis of Variance)

iii) Run test

iv) Sign test

v) Mann Whitney U test

vi) The Kruskal- Wallis test