Volume 2

RESEARCH METHODOLOGY

(Methods and Techniques)

Chief Editor

Dr. P. Madhavasarma, Principal,
Saraswathy College of Engineering & Technology,
Olakkur, Tindivanam, Villupuram.

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Rajani Adam
Kripa Drishti Publications, Pune.

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1. Sampling Fundamentals

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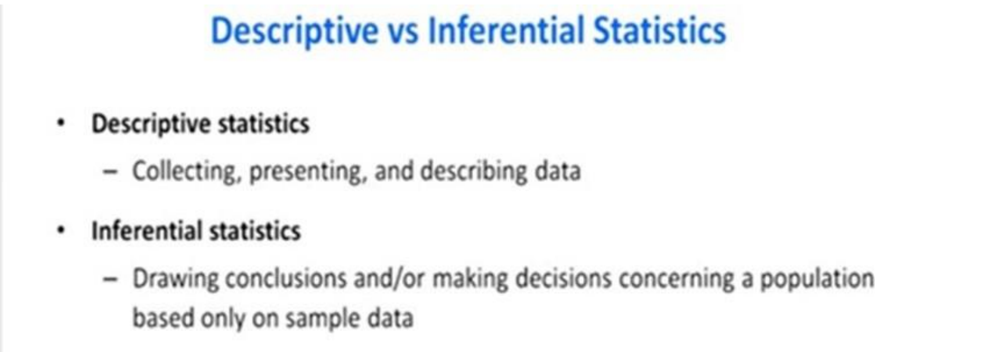
1.1 Introduction:

Before providing the idea of sampling we define population first. Population is a group of items, units. It can be finite or infinite or hypothetical.

Examples: Workers in a factory is an example of finite population. All stars in the sky is an example of infinite population.

In other words, if the number of items constituting population is fixed, it is known as finite population. If the population consists of an infinite number of items, it is called infinite population.



1.2 Sample:

A finite subset of items in population is called sample. Sampling is a part of our day-to-day life. For example, a housewife takes one or two grains of rice from cooking pan and decides whether the rice is cooked or not.

Why Sampling?:

Complete enumeration is much more expensive and time consuming. More errors are happened due to greater volume of work.

Random Sampling:

A random sample is one in which each unit of population has an equal chance of being included in it. If sample size in n and population size in N, there are NCn possible samples.

Random Versus Nonrandom Sampling

- **Random sampling**
  - Every unit of the population has the same probability of being included in the sample.
  - A chance mechanism is used in the selection process.
  - Eliminates bias in the selection process
  - Also known as probability sampling
- **Nonrandom Sampling**
  - Every unit of the population does not have the same probability of being included in the sample.
  - Open the selection bias
  - Not appropriate data collection methods for most statistical methods
  - Also known as non-probability sampling

Population Parameter:

It is a population constant from the population-(i) Population mean(μ), (II)Population variance(σ2) etc.

(Sample) Statistics:

It is a statistical measure computed from sample observations. It is also a random variable but not necessarily parameter.

1. Sample mean($\overline{x}$), 2.sample variance(s^2)

Definitions: Let x1, x2………..x_n be a random sample of size n from a population of size N then

$$\bar{x} = \frac{\sum x_i}{n} = \frac{x_1 + x_2 + \cdots + x_n}{n}$$

Population Variance	Sample Variance
$\sigma^2 = \frac{\sum_{i=1}^{N}(x_i - \mu)^2}{N}$	$s^2 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}$
σ^2 = population variance x_i = value of i^{th} element μ = population mean N = population size	s^2 = sample variance x_i = value of i^{th} element $\overline{x}$ = sample mean n = sample size

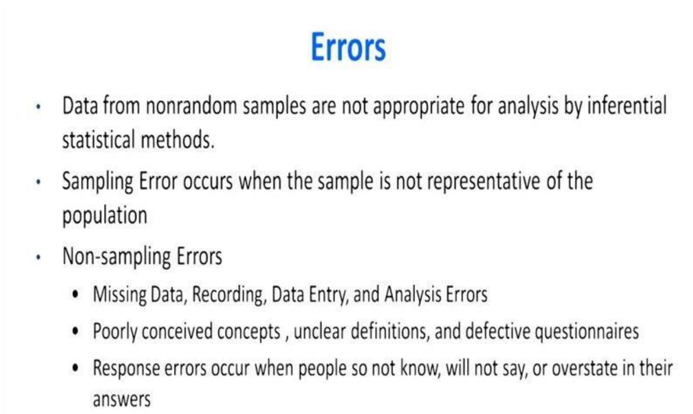
- If n ≥ 30, the sampling is known as large sample.
- If n < 30, the sampling is known as small sampling.

Difference between a statistic and a parameter?

The difference between a statistic and a parameter is that statistics describe a sample. A parameter describes an entire population.

Sampling Distribution:

A sampling distribution is a probability distribution of a statistic obtained from a larger number of samples drawn from a specific population.



Standard Error:

The standard error (SE) is very similar to standard deviation (square root of variance). Both are measures of spread. The higher the number, the more spread out your data is.

To put it simply, the two terms are essentially equal—but there is one important difference. While the standard error uses statistics (sample data) standard deviations use parameters (population data).

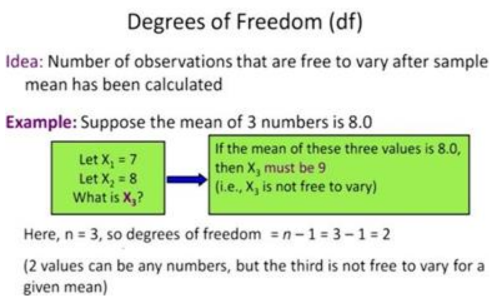
Formula for Standard Error (SE):

SE ($\bar{x}$) = – – s^2, n-: sample size, N: population size

If N is large then 1/N is negligible. Hence SE ($\bar{x}$) = s^2 = s/ –

Degrees of Freedom:

Degrees of Freedom (df) refers to the maximum number of logically independent values, which are values that have the freedom to vary, in the data sample. If n is the number of independent observation of a random sample and k is the number of population parameters which are calculated using sample data, then df=n-k.



Simple Random Sampling with Replacement (Srswr):

If the units are drawn one by one in such a way that a unit drawn at a time is replaced by back to the population before the next draw, it is known as srswr.

In this type of sampling from a population size N, the probability of selection of unit is 1/N in each draw.

Simple Random Sampling without Replacement (Srswor)

In this method the unit selected once is not included in the population at any subsequent draw. The probability of drawing a unit from a population of N units at rth draw is 1/(N-r+1).

In simple random sampling, the probability of selection of any sample of size n from a population of size N is

$1/\ {}^{N}C_{n.}$

1.3 Estimator:

An estimator is a rule or a function of variates for estimating the population parameters. An estimator is itself a random variable.

For example, estimator for mean is $\bar{x} = \frac{\Sigma\ x_i}{n} = \frac{x_1 + x_2 + \cdots + x_n}{n}$ which depends on sample values xi.

- If a random sample of size n is taken from a population having the mean μ and variance σ^2, then x a random variable whose distribution is mean μ.
- The central limit theorem states that if you have a population with mean μ and standard deviation σ and take sufficiently large random samples from the population with replacement, then the distribution of the sample means will be approximately normally distributed. This will hold true regardless of whether the source population is normal or skewed, provided the sample size is sufficiently large (usually $n > 30$). If the population is normal, then the theorem holds true even for samples smaller than 30. In fact, this also holds true even if the population is binomial, provided that min (np, n (1-p))> 5, where n is the sample size and p is the probability of success in the population. This means that we can use the normal probability model to quantify uncertainty when making inferences about a population mean based on the sample mean.

For the random samples we take from the population, we can compute the mean of the sample means:

$$\mu_{\bar{X}} = \mu$$

and the standard deviation of the sample means:

$$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$$

If the Population is not Normal- Central Limit Theorem

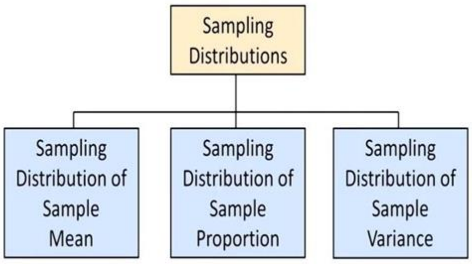
We can apply the Central Limit Theorem:

- Even if the population is not normal,
- sample means from the population will be approximately normal as long as the sample size is large enough.

Properties of the sampling distribution:

$$\mu_{\bar{x}} = \mu \quad \text{And} \quad \sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

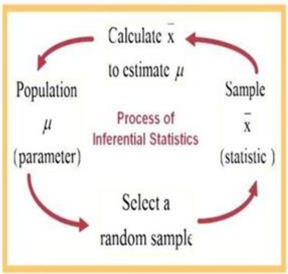
Types of sampling distributions



Distribution of the Sample Mean:

Sampling Distribution of $\bar{X}$

Proper analysis and interpretation of a sample statistic requires knowledge of its distribution.



The statistic used to estimate the mean of a population, μ, is the sample mean. $\bar{X}$

If X has a distribution with mean μ, and standard deviation σ, and is approximately normally distributed or n is large, then $\bar{X}$ is approximately normally distributed with mean μ and **standard Error** $\sigma/\sqrt{n}$.

When σ Is Known:

If the standard deviation, σ, is known, we can transform **known** to an approximately standard normal variable, the test statistic:

$$Z = \frac{\bar{X} - \mu}{\left(\frac{\sigma}{\sqrt{n}}\right)}$$

Example:

If μ=20, and σ=5. Suppose we draw a sample of size n=16 from this population and want to know how likely we are to see a sample average greater than 22, that is P ($\bar{X}$ > 22)?

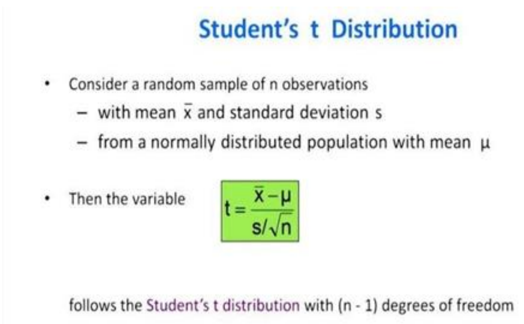
$$z = \frac{22 - 20}{\left(\frac{5}{\sqrt{16}}\right)} = 1.6$$

So the probability that the sample mean will be >22 is the probability that Z is > 1.6 We use the Z table to determine this:

P(> 22) = P(Z > 1.6) = 0.0548.

When σ Is Unknown:

If the standard deviation, σ, is **unknown**, we cannot transform to $\bar{X}$ standard normal. However, we can estimate σ using the sample standard deviation, *s*, and transform $\bar{X}$ to a variable with a similar distribution, the ***t distribution***. There are actually many t distributions, indexed by degrees of freedom (df). As the degrees of freedom increase, the t distribution approaches the standard normal distribution.



If X is approximately normally distributed, then test statistics:

$$t = \frac{\bar{X} - \mu}{\left(\frac{s}{\sqrt{n}}\right)}$$

has a t distribution with (n-1) degrees of freedom (df)

Example:

In the previous example we drew a sample of n=16 from a population with μ=20 and σ=5. We found that the probability that the sample mean is greater than 22 is P (> 22) = 0.0548. Suppose that is unknown and we need to use s to estimate it. We find that s = 4. Then we calculate t, which follows a t-distribution with df = (n-1) = 24.

$$t = \frac{22 - 20}{\left(\frac{4}{\sqrt{16}}\right)} \quad =2.0$$

If samples values are not independent

- If the sample size n is not a small fraction of the population size N, then individual sample members are not distributed independently of one another
- Thus, observations are not selected independently
- A correction is made to account for this:

$$Var(\bar{X}) = \frac{\sigma^2}{n}\frac{N-n}{N-1} \quad \text{or} \quad \sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}\sqrt{\frac{N-n}{N-1}}$$

1.3.1 Unbiased Estimate:

A statistics t=t(x1,x2,………….xn) a function of samples values x1,x2,………….xn is an unbised estimate of population parameter θ, if E(t)= θ. In other words if E(statistic)=parameter.

Sampling distribution of sample proportion:

P equal to the proportion of populations having some characteristics, we can call it as P is the population proportion. This sample proportion we are going to call it as a small. It provides an estimate of P.

Z-Value for Proportions

Standardize $\hat{p}$ to a Z value with the formula:

$$Z = \frac{\hat{p} - P}{\sigma_{\hat{p}}} = \frac{\hat{p} - P}{\sqrt{\frac{P(1-P)}{n}}}$$

Example

- if $P = .4$ and $n = 200$, what is $P(.40 \le \hat{p} \le .45)$?

Find: $\sigma_{\hat{p}}$

$$\sigma_{\hat{p}} = \sqrt{\frac{P(1-P)}{n}} = \sqrt{\frac{.4(1-.4)}{200}} = .03464$$

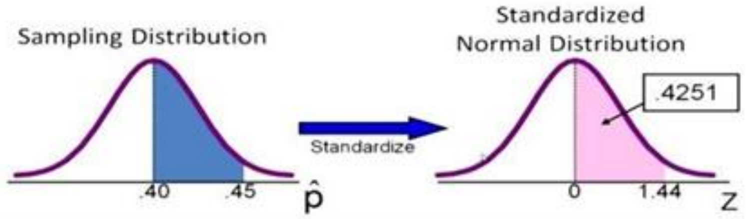
Convert to standard normal:

$$P(.40 \le \hat{p} \le .45) = P\left(\frac{.40 - .40}{.03464} \le Z \le \frac{.45 - .40}{.03464}\right)$$
$$= P(0 \le Z \le 1.44)$$

Example

if $P = .4$ and $n = 200$, what is $P(.40 \le \hat{p} \le .45)$?

Use standard normal table: $P(0 \le Z \le 1.44) = .4251$



Z value is 0 to 1.44 which we got 0.4251. So, now we have seen this one we will go to the sampling distribution of sample variance.

- The sampling distribution of sample variance has the mean population variance. So, what is the meaning in that one is, from the population, you take different sample for that sample you find the sample variance we know of that sample variance is equal to population variance but when you take the from the normal population, if you take some sample, then, you find the sample variance.

Sample Variance

- Let $x_1, x_2, \ldots, x_n$ be a random sample from a population. The sample variance is

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

- the square root of the sample variance is called the sample standard deviation
- the sample variance is different for different random samples from the same population

Sampling Distribution of Sample Variances

- The sampling distribution of s^2 has mean σ^2

$$E(s^2) = \sigma^2$$

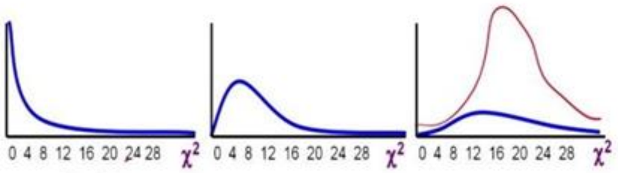
- If the population distribution is normal then

$$\frac{(n-1)s^2}{\sigma^2}$$

has a χ^2 distribution with $n-1$ degrees of freedom

The Chi-square Distribution

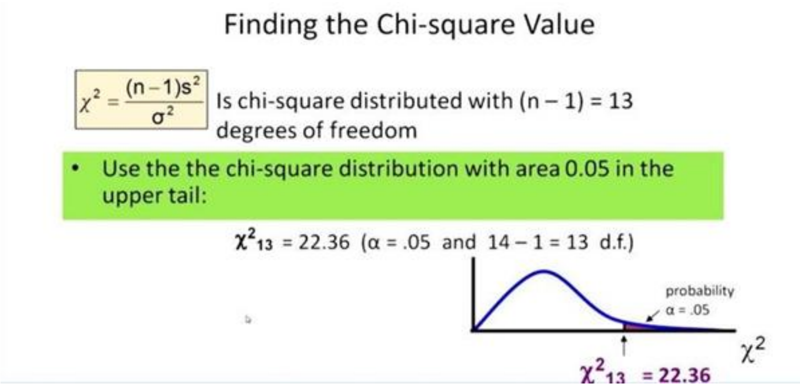
- The chi-square distribution is a family of distributions, depending on degrees of freedom: $d.f. = n - 1$



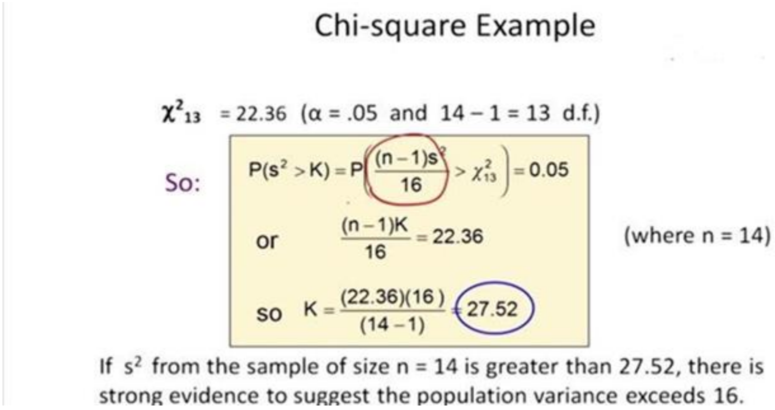
The chi-square example:

A commercial freezer must hold their selected temperature with a little variation specification called for a standard deviation of no more than 4 degrees that is the variance 16 degree square you should not exceed 16, and the standard deviation 4. For a sample of 14 freezers is to be tested what is the upper limit of the sample variance such that the probability of exceeding this limit given that the population standard deviation is 4 is less than 0.05.

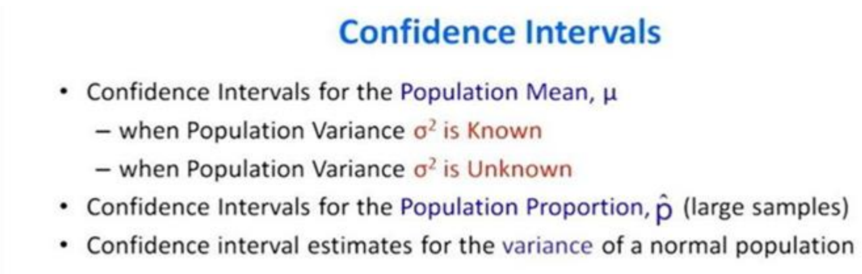
- What is it asking, what is the probability of sample variance that the, the probability of exceeding this limit is less than 0.05?



So, first thing is we have to find out the Chi square value for n minus 1 degrees of freedom. This is a chi-square distribution there are 14 sample is n the degrees of freedom is for 13. 14 minus 1 13, so, the corresponding alpha is equal to 0.05, is 22.36.



1.3.2 Confidence Interval Estimation:



- In the confidence interval, what we are going to see the confidence intervals for the population mean there are two possibilities: When the population variance Sigma square is known other case is when population variance Sigma square is unknown.
- Confidence Interval, How much uncertainty is associated with the point estimate of the population parameter because when we say, the temperature is 35 degree how much uncertainty is associated with that point estimate. That uncertainty is expressed with the help of confidence interval. An estimate provides more information about the population characteristics than does a point estimate.

So, when compared to point estimate, interval estimate is giving more information about the population. Such interval estimates are called confidence intervals.

So, for example, if we say this is the population we are taking different sample say, the population mean may be say 40.

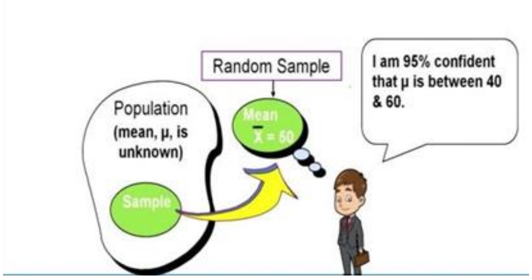
We have taken various sample with help of sample mean, we can predict what will be the lower limit and upper limit of this population mean.

For example, if we say, 35 to 45 this interval is nothing but confidence interval.

Confidence Interval and Confidence Level

- If P(a < θ < b) = 1 - α then the interval from a to b is called a 100(1 - α)% confidence interval of θ.
- The quantity (1 - α) is called the confidence level of the interval (α between 0 and 1)
  - In repeated samples of the population, the true value of the parameter θ would be contained in 100(1 - α)% of intervals calculated this way.
  - The confidence interval calculated in this manner is written as a < θ < b with 100(1 - α)% confidence

Estimation Process

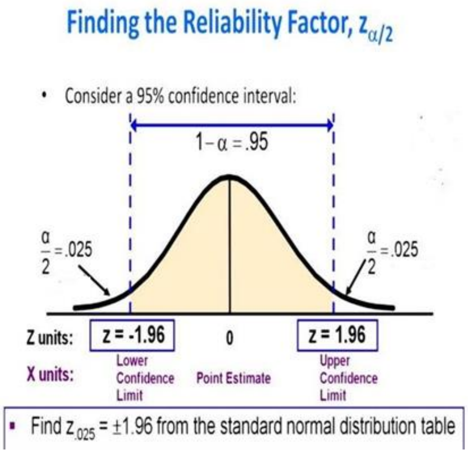


General Formula

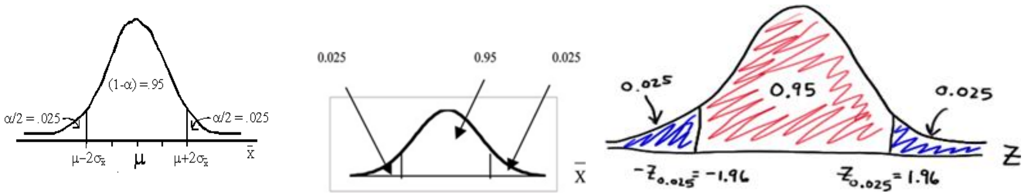
- The general formula for all confidence intervals is:

Point Estimate ± (Reliability Factor)(Standard Error)

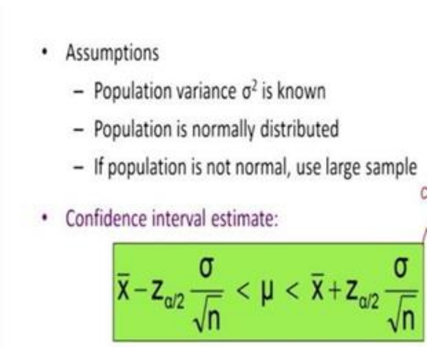
- If you use a standard error, σ/√n, so x-bar + or - Z (σ/√n) is nothing but the formula for confidence interval. So, when you say + it is upper limit if it is - it is lower limit.
- We look at how to find out the reliability factor that is Z α/2. For example, if I suppose, if you want to know something at 95% confidence level, so this is 95% confidence level so the remaining is 5%, when you divide this 5% by 2 see the right hand side you will get is 0.025. The left hand she will get 0.025. When you look at the Z table, when the right hand side is 0.025, the corresponding Z value is 1.96 on right hand side.



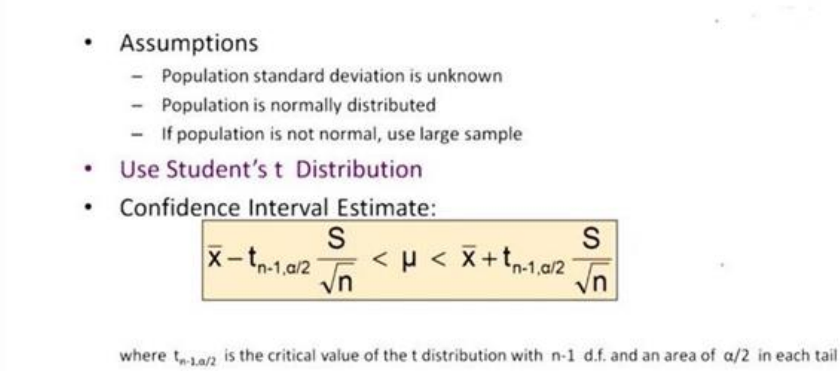
The 95% confidence interval for μ

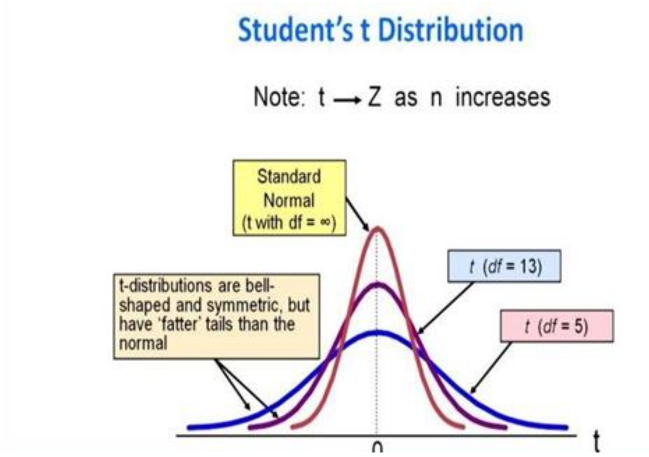


Confidence interval for μ when σ known:

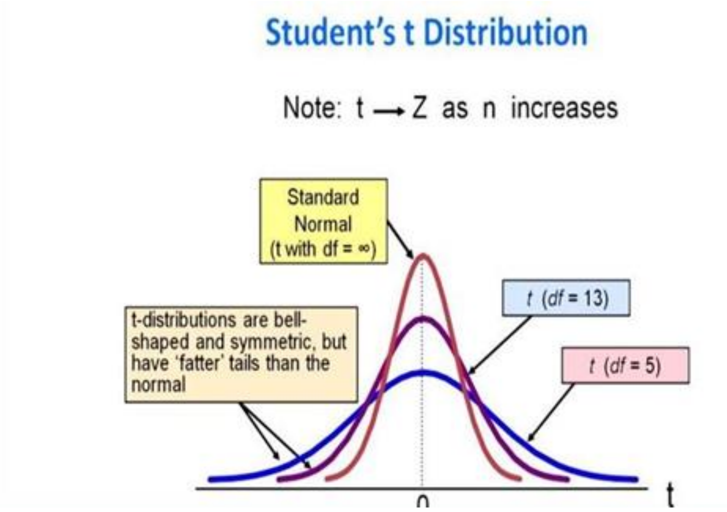


Confidence interval for μ when σ unknown:





When the sample size increases for the t test so the behavior of Z distribution t distribution is same



Example

A random sample of $n = 25$ has $\bar{x} = 50$ and $s = 8$. Form a 95% confidence interval for μ

– d.f. = $n - 1 = 24$, so $t_{n-1,\alpha/2} = t_{24,.025} = 2.0639$

The confidence interval is

$$\bar{x} - t_{n-1,\alpha/2}\frac{S}{\sqrt{n}} < \mu < \bar{x} + t_{n-1,\alpha/2}\frac{S}{\sqrt{n}}$$

$$50 - (2.0639)\frac{8}{\sqrt{25}} < \mu < 50 + (2.0639)\frac{8}{\sqrt{25}}$$

$$46.698 < \mu < 53.302$$

Confidence Intervals for the Population Variance

The (1 - α)% confidence interval for the population variance is

$$\frac{(n-1)s^2}{\chi^2_{n-1,\alpha/2}} < \sigma^2 < \frac{(n-1)s^2}{\chi^2_{n-1,1-\alpha/2}}$$

- An example you are testing the speed of batch of computer processors you collect the following data, sample sizes 17 sample mean is 3004 samples, standard deviation is 74 assume the population is normal determined 95% confidence interval for σXbar2, here σXbar2 is nothing but lower limit upper limit of the sampling variance.

Example

You are testing the speed of a batch of computer processors. Y
collect the following data (in Mhz):

Sample size	17
Sample mean	3004
Sample std dev	74

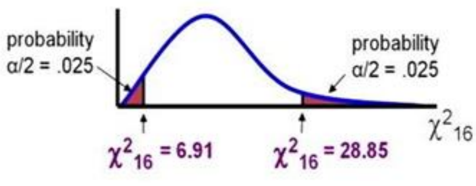
Assume the population is normal. Determine the 95% confidence interval for σ_x^2

Finding the Chi-square Values

- n = 17 so the chi-square distribution has (n – 1) = 16 degrees of freedom
- α = 0.05, so use the the chi-square values with area 0.025 in each tail:

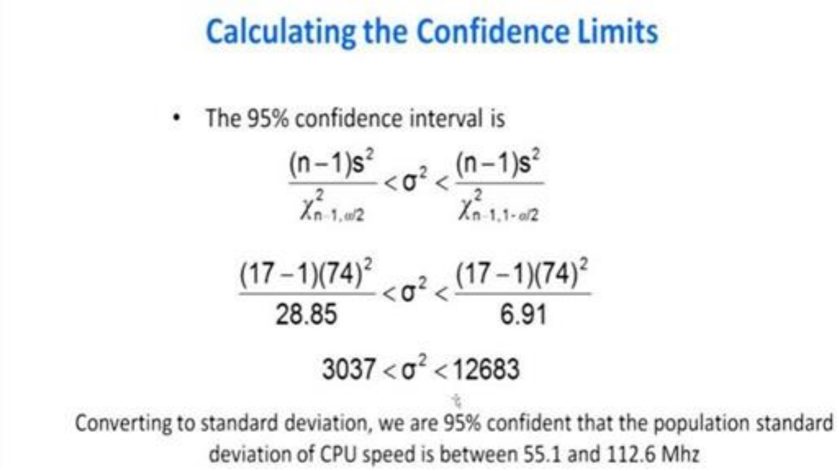
$$\chi^2_{n-1,\alpha/2} = \chi^2_{16,0.025} = 28.85$$

$$\chi^2_{n-1,1-\alpha/2} = \chi^2_{16,0.975} = 6.91$$



So, n equal to 17 then chi square distribution has the n – 1, 16 degrees of freedom when alpha equal to 0.05 because it is we are finding upper limit lower limit we got 2 divided by 2 so 0.025.

so, when it is alpha by 2 it is 28.25 so what will happen this is the right side limit when you want to know the left side limit you have to, in the chi square table when area equal to 1 - 0.025 that area you have to find out that probability when the degrees of freedom is 16 so corresponding is 6.91.



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2. Testing of Hypothesis

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2.1 Introduction:

Many problems in engineering require, that whether decide whether to accept or reject a statement about some parameter. The statement is called hypothesis, and the decision-making procedure about the hypothesis is called hypothesis testing.

This is one of the most useful aspects of statistical inference, since many types of decision-making problems, tests, or experiments in the engineering world can be formulated as hypothesis-testing problems.

Furthermore, as we will see, there is a very close connection between hypothesis testing and confidence intervals.

Statistical hypothesis testing and confidence interval estimation of parameters are the fundamental methods used at the data analysis stage of a comparative experiments.

2.1.1 Population:

A population is statistics means a set of objects or mainly the set of numbers which are measurements or observations pertaining to the objects. The population is finite or infinite according to the number of elements of the set is finite or infinite.

2.1.2 Sample:

A part selected from population is called a sample. The process of a sample is called sample.

2.1.3 Parameters and Statistics:

The statistical constants of the population, such as mean (μ), standard deviation (σ) are called parameters.

Parameters are denoted by Greek letters.

The mean $\bar{x}$, standard deviation S of a sample are known as statistics. Statistics are noted by Roman letters.

2.1.4 Symbols for Population and Samples:

Characteristics	Population	Sample
	Parameter	**Statistic**
Symbols	Population size = N	Sample size = n
	Population mean = μ	Sample mean = $\bar{x}$
	Population standard deviation = σ	Sample standard deviation = s
	Population proportion = p	Population proportion = p

2.2 Hypothesis Testing or Significance Testing:

Hypothesis is usually considered as the principal instrument in research. The main aim in many studies of research is to check whether the data collected support certain predictions or conditions. It is very essential to a research worker to understand the meaning and nature of hypothesis. The researcher always plans or formulate a hypothesis in the beginning of the problem. A hypothesis is an assertion or conjecture concerning one or more populations. In short, hypothesis testing enables us to make probability statements about population parameter.

The word hypothesis combination of two words: **Hypo + Thesis = Hypothesis**. That is, "Hypo" means tentative or subject to the verification and "Thesis" means statement about solution of a problem.

Alterative meaning of the word hypothesis which is composed of two words **Hypo + Thesis** – 'Hypo' means composition of two or more variables which is to be verified. "Thesis" means position of these variables in the specific frame of reference. In simply, we can say a hypothesis is an assumption about the population parameter.

A process of testing of the significance regarding the parameters of the population on the basis of sample drawn from it is called a "Test of hypothesis" (Or) "Test of Significance. In many cases, researchers may find that the results of an experiment do not support the original hypothesis. When writing up these results, the researchers might suggest other options that should be explored in future studies.

2.2.1 Characteristic of Good Hypothesis:

a. Hypothesis should be specific, clear and precise.
b. Hypothesis should be capable of being tested.
c. Hypothesis should state relationship between variables.
d. Hypothesis should be limited in scope.
e. Hypothesis should be stated as far as possible in most simple terms so that the same is easily understandable by all concerned.
f. Hypothesis should be amenable to testing within a reasonable time.
g. Hypothesis must explain empirical reference.
h. Hypothesis should not be contradictory.

2.2.2 Role of Hypothesis:

The hypotheses play a vital role in the scientific studies. Some of the important role and functions of the hypothesis –

a. Helps in the testing of the theories.
b. Serves as a great platform in the investigation activities.
c. Provides guidance to the research work or study.
d. Hypothesis sometimes suggests theories.

2.2.3 Sources of Hypotheses:

The main sources of hypotheses are as follows:

a. Specialization of an educational field.
b. Published studies, abstracts research journals, hand books, seminars on the issue, current trends on the research area.
c. Instructional programs persuaded.
d. Analyze of the area studied.
e. Considering existing practices and needs.
f. Extension of the investigation.
g. Offshoots of research studies in the field.

2.2.4 Limitations of the Test of Hypotheses:

a. Test do not explain the reasons as to why do the difference exist, say between the means of the two samples. They simply indicate whether the difference is due to fluctuations of sampling or because of other reasons but the tests do not tell us as to which is/are the other reason(s) causing the difference.
b. Results of significance tests are based on probabilities and as such cannot be expressed with full certainty.
c. Statistical inferences based on the significance tests cannot be said to be entirely correct evidences concerning the truth of the hypotheses.

2.3 Types of Hypothesis:

Hypothesis consists of two major types. They are

2.3.1 Research Hypothesis:

A research hypothesis is a tentative claim for the problem being investigated. It motivates the researcher to accomplish future course of action.

In research, the researcher determines whether or not their supposition can be supported through scientific investigation. The following are the types of research hypothesis:

2.3.2 Simple Hypothesis:

This predicts the relationship between a single independent variable (IV) and a single dependent variable (DV). **For example:** Lower levels of exercise postpartum (IV) will be associated with greater weight retention (DV).

2.3.3 Complex Hypothesis:

This predicts the relationship between two or more independent variables and two or more dependent variables.

For Example: The implementation of an evidence-based protocol for urinary incontinence (IV) will result in (DV)

a. decreased frequency of urinary incontinence episodes;
b. decreased urine loss per episode;
c. Decreased avoidance of activities among women in ambulatory care settings.

2.3.4 Directional Hypothesis:

This may imply that the researcher is intellectually committed to a particular outcome. They specify the expected direction of the relationship between variables i.e. the researcher predicts not only the existence of a relationship but also its nature.

For Example: High school students who participate in extracurricular activities have a lower GPA than those who do not participate in such activities.

2.3.5 Non-Directional Hypothesis:

It cannot stipulate the direction of the relationship.

For Example: The academic performance of high school students is related to their participation in extracurricular activities.

2.3.6 Associative Hypothesis:

It can propose relationships between variables, when one variable changes, the other changes. Do not indicate cause and effect.

2.3.7 Causal Hypothesis:

Causal hypotheses propose a cause and effect interaction between two or more variables. The independent variable is manipulated to cause effect on the dependent variable. The dependent variable is measured to examine the effect created by the independent variable.

For example: High school students who participate in extracurricular activities spend less time studying which leads to a low GPA.

2.3.8 Inductive and Deductive Hypotheses:

Inductive hypotheses are formed through inductively reasoning from many specific observations to tentative explanations. Deductive hypotheses are formed through deductively reasoning implications of theory.

2.3.9 Statistical Hypothesis:

Statistical hypothesis is a statement about the population which we want to verify on the basis of sample taken from population. Statistical hypothesis is stated in such a way that they may be evaluated by appropriate statistical techniques. The following are the types of statistical hypotheses:

a. **Null Hypothesis (H0)**: A statistical hypothesis that states that there is no difference between a parameter and a specific value, or that there is no difference between two parameters.
b. **Alternative Hypothesis (H1)**: A statistical hypothesis that states the existence of a difference between a parameter and a specific value, or states that there is a difference between two parameters. Alternative hypothesis is created in a negative meaning of the null hypothesis.

2.4. Basic Concepts of Testing of Hypotheses:

2.4.1 The Level of Significance:

The level of significance (α) is the probability of rejecting a true null hypothesis that is the probability of "Type I error" and is denoted by α. The frequently used values of α are 0.05; 0.01; 0.1 etc.

When, $\alpha = 0.05$ it means that level of significance is 5%.

$\alpha = 0.01$ it means 1% level of significance.

$\alpha = 0.01$ it means 10% level of significance.

In fact, α specifies the critical region. A competed value of the test statistic that falls in the critical region (CR) is said to be significant.

2.4.2 Critical / Rejection Region:

The critical region (CR) or rejection region (RR) is the area under the curve beyond certain limits in which the population value is unlikely to fall by chance only when the null hypothesis is assumed to be true.

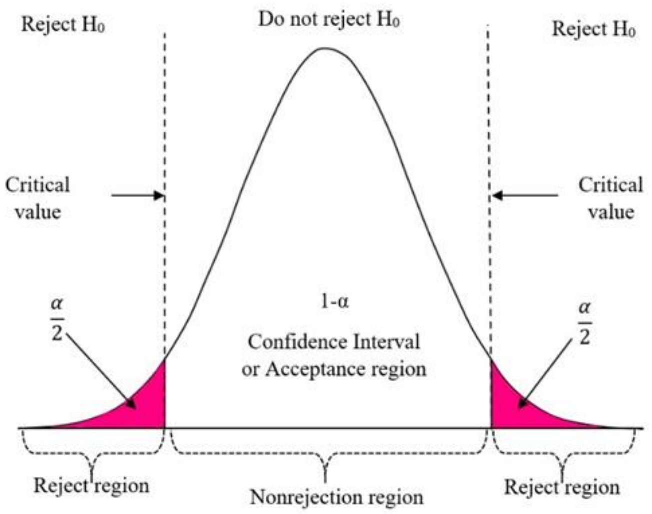
If an observed value falls in this region H0 is rejected and the observed value is said to be significant. In a word, the region for which H0 is rejected is called critical region or rejection region.

2.4.3 Confidence Interval:

The interval which marked by limits within which the population value lies by chance and the hypothesis is consider to be tenable. If an observed value falls in confidence interval H0 is accepted.

2.4.4 Critical Values:

The values of the test statistic which separates critical region from confidence region (acceptance region) are called critical values.



2.4.5 Decision rule or Test of Hypothesis:

A decision rule is a procedure that the researcher uses to decide whether to accept or reject the null hypothesis. The decision rule is a statement that tells under what circumstances to reject the null hypothesis.

The decision rule is based on specific values of the test statistic (e.g., reject H0 if Calculated value > table value at the same level of significance)

2.4.6 Types of Error:

In testing of hypotheses, there are basically, we have two types of errors in testing of

a. **Type I Error:** To reject the null hypothesis when it is true is to make what is known as a type I error. The level at which a result is declared significant is known as the type I error rate, often denoted by α.
b. **Type II Error:** If we do not reject the null hypothesis when in fact there is a difference between the groups, we make what is known as a type II error. The type II error rate is often denoted as β.

In a tabular form,

Truth of the Population	Decision	
	Accept H_0	Reject H_0
H_0 (True)	Correct Decision	Type I error (α error)
H_0 (False)	Type II error (β Error)	Correct decision

2.4.7 Standard Error:

The standard error is an estimate of the standard deviation of a statistic. The standard error is used to compute other measures like confidence intervals and margins of error.

The standard error is computed from known sample statistics, and it provides an unbiased estimate of the standard deviation of the statistic. Reciprocal of standard error is known as precision. The following table shows standard error for the respected statistics of the population:

Sr. No.	Statistic	Standard error
1.	$\bar{x}$	$\frac{\sigma}{\sqrt{n}}$
2.	s	$\sqrt{\frac{\sigma^2}{2n}}$
3.	s^2	$\sigma^2\sqrt{\frac{2}{n}}$
4.	$\overline{x_1} - \overline{x_2}$	$\sqrt{\frac{\sigma^2}{n_1} + \frac{\sigma^2}{n_2}}$
5.	$s_1 - s_2$	$\sqrt{\frac{\sigma^2}{2n_1} + \frac{\sigma^2}{2n_2}}$
6.	$p_1 - p_2$	$\sqrt{\frac{P_1Q_1}{n_1} + \frac{P_2Q_2}{n_2}}$
7.	Observed sample proportion p	$\sqrt{\frac{PQ}{n}}$

2.4.8 Degree of Freedom:

Degree of freedom refers to the number of values which are free to vary after we have given the number of restrictions imposed upon the data. It is commonly abbreviated by df.

2.4.9 One- Tailed Test:

A test of statistical hypothesis, where the region of rejection is on only one side of the sampling distribution, is called a one tailed test and it is represented as

H_0	$\mu \geq \mu_0$	$\mu \leq \mu_0$
H_1	$\mu < \mu_0$	$\mu > \mu_0$

One- tailed Test are classified as

a. Right Tailed Test:
A test in which critical region is located in right tail of the distribution of test statistic is called right tailed test or upper one tailed test.

b. Left Tailed Test:
A test in which critical region is located in left tail of the distribution of test statistic is called left tailed test or lower one tailed test.

For example: Suppose,

H_0 : The population mean $\mu \leq 10$ and
H_1 : The population mean $\mu > 10$.

The region of rejection which consist of a range of numbers come across on the right side of sampling distribution. i.e., a set of numbers greater than 10.

2.4.9 Two-Tailed Test:

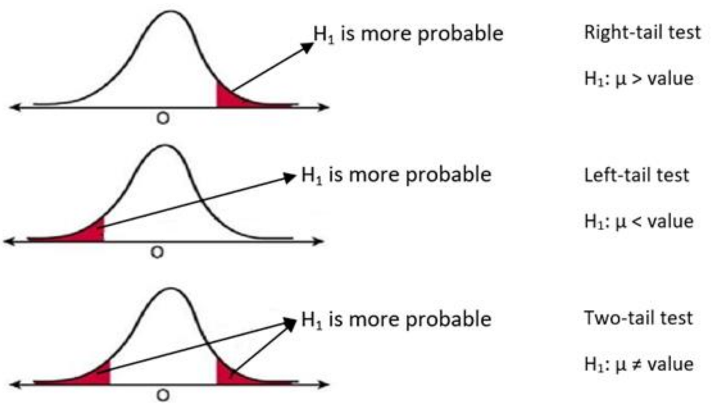
A test of statistical hypothesis, where the region of rejection is on both sides of the sampling distribution, is called a two-tailed test. The hypotheses are represented as

$H_0: \theta = \theta_0; H_1: \theta \neq \theta_0.$

For example: Suppose,

H_0: The population mean $\mu = 10$ and
H_1: The population mean $\mu > 10$ or $\mu < 10$.

The region of rejection which consist of a range of numbers come across on both sides of sampling distribution; i.e., the region of rejection would consist partly of numbers that were less than 10 and partly of numbers that were greater than 10.



Large and Small Samples:

a. A sample is small if its size $n < 30$.
b. A sample is large if its size $n \geq 30$.

2.5 Purpose of Testing of Hypotheses:

The main purposes of testing of hypotheses which can be classified as:

a. Parametric Tests or Standard Tests:

Parametric tests usually assume certain properties of the parent population from which we draw samples. Assumptions like observations come from a normal population, sample size is large, assumptions about the population parameters like mean, variance, etc., must hold good before parametric tests can be used.

b. Non-Parametric Tests or Distribution-Free Test:

Non-parametric tests usually assume only nominal or ordinal data, whereas parametric tests require measurement equivalent to at least an interval scale. As a result, non-parametric tests need more observations than parametric tests to achieve the same size of Type I and Type II errors.

2.5.1 Important Parametric Tests:

All these tests are based on the assumption of normality i.e., the source of data is considered to be normally distributed.

a. **z-test:** It is based on the normal probability distribution and is used for judging the significance of several statistical measures, particularly the mean. This is a most frequently used test in research studies. This test is used even when binomial distribution or t-distribution is applicable on the presumption that such a distribution tends to approximate normal distribution as 'n' becomes larger. z-test is generally used for comparing the mean of a sample to some hypothesized mean for the population in case of large sample, or when population variance is known. z-test is also used for judging his significance of difference between means of two independent samples in case of large samples, or when population variance is known. z-test is also used for comparing the sample proportion to a theoretical value of population proportion or for judging the difference in proportions of two independent samples when n happens to be large. Besides, this test may be used for judging the significance of median, mode, coefficient of correlation and several other measures.

b. **t- test:** It is based on t-distribution and is considered an appropriate test for judging the significance of a sample mean or for judging the significance of difference between the means of two samples in case of small sample(s) when population variance is not known. In case two samples are related, we use paired t-test for judging the significance of the mean of difference between the two related samples. It can also be used for judging the significance of the coefficients of simple and partial correlations.

c. **F-test:** It is based on F-distribution and is used to compare the variance of the two-independent samples. This test is also used in the context of analysis of variance (ANOVA) for judging the significance of more than two sample means at one and the same time. It is also used for judging the significance of multiple correlation coefficients.

2.6. Procedure for Testing of Hypothesis:

2.6.1 Test for a Specified Mean (Population Mean vs Sample Mean) of Large Sample:

A random sample of size n ≥ 30 is drawn from a population. We want to test the population mean has a specified value μ_0

I. Procedure for Two-Tailed Test:

a. State the null hypothesis $H_0 : \mu = \mu_0$ and alternative hypothesis $H_1 : \mu \neq \mu_0$ (Two tailed)
b. Select the level of significance.

A	0.01 or 1% level	0.05 or 5% level
z- table value	2.58	1.96

c. Test statistic $z = \frac{\bar{x}-\mu}{\sigma/\sqrt{n}}$
d. **Conclusion:** Make the decision to reject or accept the null hypothesis.
   (i). |Test statistic value| <Table value
   null hypothesis (H_0) is accepted.
   (ii). |Test statistic value| > Table value
   null hypothesis (H_0) is rejected.

For example:

1) For α = 0.01 (1% level)
   (i). |Test statistic value| < 2.58
   null hypothesis (H_0) is accepted at 1% level.

(ii). |Test statistic value| > 2.58
null hypothesis (H_0) is rejected at 1% level.

2) For α = 0.05 (5% level)

(i). |Test statistic value| < 1.96
null hypothesis (H_0) is accepted at 5% level.

(ii). |Test statistic value| > 1.96
null hypothesis (H_0) is rejected at 5% level.

e. Summarize the Result:

II. Procedure for Testing (For One-Tailed Test):

a. State the null hypothesis $H_0 : \mu = \mu_0$ and alternative hypothesis $H_1 : \mu < \mu_0$ (left tailed)
b. Select the level of significance.

α	0.01 or 1% level	0.05 or 5% level
z- table value	- 2.33	-1.645

c. Test statistic $z = \frac{\bar{x} - \mu}{\sigma / \sqrt{n}}$
d. **Conclusion:** Make the decision to reject or accept the null hypothesis
(i). |Test statistic value| < Table value
null hypothesis (H_0) is accepted.
(ii). |Test statistic value| > Table value
null hypothesis (H_0) is rejected.
e. Summarize the result.

2.6.2 Test for the Equality of Two Mean (Sample Mean Vs Sample Mean) Of Large Sample:

a. State the null hypothesis $H_0 : \mu = \mu_0$ and alternative hypothesis $H_1 : \mu \neq \mu_0$.
b. Select the level of significance.
c. Test statistic $z = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$
d. **Conclusion:** Make the decision to reject or accept the null hypothesis.
(i). |Test statistic value| < Table value
null hypothesis (H_0) is accepted.
(ii). |Test statistic value| > Table value
null hypothesis (H_0) is rejected.
e. Summarize the result.

2.6.3 Test for a Specified Proportion (Population Proportion (vs) Sample Proportion) of Large Sample:

a. State the null hypothesis H_0 :p=P and alternative hypothesis H_1 :$p \neq P$
b. Select the level of significance.
c. Test statistic z= $\frac{p-P}{\sqrt{\frac{PQ}{n}}}$
d. **Conclusion:** Make the decision to reject or accept the null hypothesis.
   (i). |Test statistic value| <Table value
   null hypothesis (H_0) is accepted.
   (ii). |Test statistic value| > Table value
   null hypothesis (H_0) is rejected.

e. Summarize the result.

2.6.4 Test for the Equality of Two Proportions (Sample Proportion (vs) Sample Proportion) of Large Sample:

a. State the null hypothesis H_0 :$p_1 = p_2$ and alternative hypothesis H_1 : $p_1 \neq p_2$
b. Select the level of significance.
c. Test statistic z= $\frac{p_1-p_2}{\sqrt{PQ(\frac{1}{n_1}+\frac{1}{n_2})}}$, $P = \frac{n_1p_1+n_2p_2}{n_1+n_2}$, $Q = 1 - P$
d. **Conclusion:** Make the decision to reject or accept the null hypothesis.
   (i). |Test statistic value| <Table value
   null hypothesis (H_0) is accepted.
   (ii). |Test statistic value| > Table value
   null hypothesis (H_0) is rejected.
e. Summarize the result.

2.6.5 Test for a Specified Mean (Population Mean (vs) Sample Mean) of Small Samples:

a. State the null hypothesis H_0 : $\mu = \mu_0$ and alternative hypothesis H_1 : $\mu \neq \mu_0$
b. Choose the level of significance and the degrees of freedom is n-1
c. Test statistic t = $\frac{\bar{x}-\mu}{s/\sqrt{n-1}}$,
d. **Conclusion:** Make the decision to reject or accept the null hypothesis
   (i). |Test statistic value| <Table value
   null hypothesis (H_0) is accepted.
   (ii). |Test statistic value| > Table value
   null hypothesis (H_0) is rejected.
e. Summarize the result.

2.6.6 Test for the Equality of Two Mean (Sample Mean (vs) Sample Mean) of Small Samples:

a. State the null hypothesis $H_0 : \mu_1 = \mu_2$ and alternative hypothesis $H_1 : \mu_1 \neq \mu_2$
b. Calculate the table value.
c. Test statistic $t = \frac{\overline{x_1} - \overline{x_2}}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$, $S = \sqrt{\frac{n_1 s_1^2 + n_2 s_2^2}{n_1 + n_2 - 2}}$, S- Standard error
d. Degrees of freedom = $n_1 + n_2 - 2$
e. **Conclusion:** Make the decision to reject or accept the null hypothesis
   (i). |Test statistic value| < Table value
        null hypothesis (H_0) is accepted.
   (ii). |Test statistic value| > Table value
        null hypothesis (H_0) is rejected.
f. Summarize the result.

2.6.7 t - Test for Paired Sample Observations of Small Samples:

a. State the null hypothesis H_0: $\mu_2 - \mu_1 = 0$ and alternative hypothesis $H_1 : \mu_2 - \mu_1 \neq 0$
b. Calculate the table value for given level of significance with n-1 degrees of freedom.
c. Test statistic t = $\frac{\bar{d}}{s/\sqrt{n-1}}, \bar{d} = \frac{\sum d}{n}$
d. Degrees of freedom = $n - 1$
e. Conclusion: Make the decision to reject or accept the null hypothesis
   (i). |Test statistic value| <Table value
        null hypothesis (H_0) is accepted.
   (ii). |Test statistic value| > Table value
        null hypothesis (H_0) is rejected.
f. Summarize the result.

2.6.8 F - Test for Equality of Variance of Small Samples:

a. State the null hypothesis $H_0 : \sigma_1^2 = \sigma_2^2$ and alternative hypothesis $H_1 : \sigma_1^2 \neq \sigma_2^2$
b. Calculate the table value for given level of significance with $n_1 - 1,\ n_2 - 1$ degrees of freedom.
c. Test statistic
   (i). I $S_1^2 > S_2^2$f then $F = \frac{S_1^2}{S_2^2}$
   (ii). If $S_2^2 > S_1^2$ then $F = \frac{S_2^2}{S_1^2}$
   Where $S_1^2 = \frac{n_1 s_1^2}{n_1 - 1}$ and $S_2^2 = \frac{n_2 s_2^2}{n_2 - 1}$

d. **Conclusion:** Make the decision to reject or accept the null hypothesis
   (i). |Test statistic value| <Table value
        null hypothesis (H_0) is accepted
   (ii). |Test statistic value| > Table value
        null hypothesis (H_0) is rejected.
e. Summarize the result

2.6.9 χ^2 – test to test the goodness of fit:

A very powerful test for testing the significance of the discrepancy between theory and experiment was given by prof. Karl-Pearon in 1990 and is known as "Chi-square test of goodness of fit." It enables us to find if the deviation of the experiment from theory is just by chance or is it really due to the inadequacy of the theory of fit the observed data.

By this test, we test whether differences between observed and expected frequencies are significant or not.

χ^2-test statistic of goodness of fit is defined by

$\chi^2 = \sum \frac{(O-E)^2}{E}$, Where O → observed frequencies and E → Expected frequency.

2.7 Illustrations:

Example 1

The mean life time of a sample of 100 light bulbs produced by a company is computed to be 1570 hours with a standard deviation of 120 hours. If μ is the mean life time of all the bulbs produced by the company, test the hypothesis μ = 1600 hours, against the alternative hypothesis μ ≠ 1600 hours with α =0.05 and 0.01.

Solution:

Given: n=100, $\bar{x}$=1570, μ=1600, s= 120, α = 0.05 and α = 0.01.

a. The null hypothesis H_0: $\mu = 1600$
   Alternative hypothesis H_1 : μ ≠ 1600
   (Two tailed)

b. Level of significance

A	0.01 or 1% level	0.05 or 5% level
z- table value	2.58	1.96

c. Test statistic z = $\frac{\bar{x}-\mu}{s/\sqrt{n}} = \frac{1570-1600}{120/\sqrt{100}}$ = -2.5

d. Conclusion:

(i) |-2.5| ≮ 1.96
So, we reject the null hypothesis H_0

(ii) |-2.5| < 2.58
So, we accept the null hypothesis H_0 at 1% level of significance.

Thus, the mean life time of all the bulbs produced by the company is 1600 hours.

Example 2

The mean breaking strength of the cables supplied by a manufacturer is 1800 with S.D. of 100. By a new technique in the manufacturing process, it is claimed that the breaking strength of the cable has increased. In order to test this claim, a sample of 50 cables is tested and it is found that the mean breaking strength is 1850. Can we support the claim at 1% level of significance?

Solution:

Given: n=50, $\bar{x}$=1850, μ=1800, s= 100, α = 0.01.

a. The null hypothesis H_0 : $\mu = 1800$
   Alternative hypothesis H_1: μ > 1800 (Use one tailed test (right))
b. Level of significance:

A	0.01 or 1% level
z- table value	2.33

c. Test statistic z= $\frac{\bar{x}-\mu}{s/\sqrt{n}} = \frac{1850-1800}{100/\sqrt{50}}$ = 3.54
d. Conclusion: |2.33| ≮ 3.54.

   So, we reject the null hypothesis H_0 at 1% level of significance.

Hence, the mean breaking strength is greater than 1800.

Example 3

The means of two large samples of 1000 and 2000 members are 67.5 inches and 68.0 inches respectively. Can the samples be regarded as drawn from the same population of standard deviation 2.5 inches at 5 % level of significance?

Solution:

Given: n_1=1000, $\overline{x_1}$ =67.5, σ_1=σ_2= 2.5,

n_2=2000, $\overline{x_1}$=68.

a. The null hypothesis H_0 : $\mu_1 = \mu_2$ [No significant difference]
   Alternative hypothesis H_1 : $\mu_1 \neq \mu_2$ (Use one tailed test (right))
b. Level of significance:

A	0.05 or 5% level
z- table value	1.96

c. Test statistic $z = \frac{\overline{x_1}-\overline{x_2}}{\sqrt{\frac{\sigma_1^2}{n_1}+\frac{\sigma_2^2}{n_2}}} = \frac{67.5-68}{\sqrt{\frac{(2.5)^2}{1000}+\frac{(2.5)^2}{2000}}} = -5.16$

d. Conclusion: $|5.16| \nless 1.96$.

So, we reject the null hypothesis H_0 at 5% level of significance.

∴ there is a significant difference between them.

Example 4

The mean lifetime of a sample of 25 bulbs is found as 1550 hours with a S.D. of 120 hours. The company manufacturing the bulbs claims that the average life of their bulbs is 1600 hours. Is the claim acceptable at 5% level of significance?

Solution:

Given: n=25, $\bar{x}$=1550, s = 120, μ=1600

a. The null hypothesisH_0: μ $= 1600$
alternative hypothesis H_1: μ < 1600 (Use one tailed test (left))

b. Level of significance: 5%
degrees of freedom = n -1= 24
table value =1.711

c. Test statistic $t = \frac{\bar{x}-\mu}{s/\sqrt{n-1}} = \frac{1550-1600}{120/\sqrt{24}} = -2.04$

d. Conclusion: $|-2.08| \nless 1.711$.

So, we reject the null hypothesis H_0 at 5% level of significance.

∴ The claim of the company cannot be accepting at 5% level of significance.

Example 5

The average number of articles produced by two machines per day are 200 and 250 with S.D 20 and 25 respectively on the basis of records of 25 days production. Can you regard both the machines equally efficient at 1% level of significance?

Solution:

Given: n_1=25, $\overline{x_1}$ =200, s_1=s_1=20, $s_2 = 25$, n_1=25, $\overline{x_1}$ =250.

a. The null hypothesis H_0: μ $= 1600$
alternative hypothesis H_1: μ < 1600 (Use one tailed test (left))

b. Level of significance: 1%

degrees of freedom = $n_1 + n_2 - 2$ = 48

table value =2.58

c. Test statistic t =$\frac{\overline{x_1}-\overline{x_2}}{S\sqrt{\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} = \frac{200-250}{(23.11)\sqrt{\left(\frac{1}{25}+\frac{1}{25}\right)}} = -0.33$,

Where S=$\sqrt{\frac{n_1 s_1^2+n_2 s_2^2}{n_1+n_2-2}}$, S - Standard error

d. Conclusion: |-0.33| < 2.58.

So, we accept the null hypothesis H_0at 1% level of significance.

∴ The machines are equally efficient.

Example 6

An IQ test was administrated to 5 persons before and after they were trained. The results are given below:

Candidates:	I	II	III	IV	V
IQ before training	110	120	123	132	125
IQ after training	120	118	125	136	121

Test whether there is any change in IQ after the training programme.

Solution:

a. the null hypothesis H_0 :$\mu_2 - \mu_1$= 0 and alternative hypothesis H_1 : $\mu_2 - \mu_1 \neq 0$.

b. Calculate the table value:

The table value for degrees of freedom = n-1= 4 at α=0.005 is 4.604

c. Test statistic t =$\frac{\bar{d}}{s/\sqrt{n-1}}$, $\bar{d} = \frac{\sum d}{n}$

Candidates	**IQ Before Training (x)**	**IQ after Training (y)**	**d=$y-x$**	d^2
I	110	120	10	100
II	120	118	-2	4
III	123	125	2	4
IV	132	136	4	16
V	125	121	-4	16
			$\sum d = 10$	$\sum d^2 = 140$

$\bar{d} = \frac{\sum d}{n} = \frac{10}{5}$=2,

Standard deviation (s)= $\sqrt{\frac{\sum d^2}{n} - \left[\frac{\sum d}{n}\right]^2} = \sqrt{\frac{140}{5} - \left[\frac{10}{5}\right]^2} = \sqrt{28 - 4} = \sqrt{24}$ = 4.899

$$t = \frac{\bar{d}}{s/\sqrt{n-1}} = \frac{2}{4.899/\sqrt{3}} = 0.7071$$

d. **Conclusion:** |0.7071| < 4.899

So, we accept the null hypothesis H_0 is accepted.

∴ there is no significant change in IQ due to the training program.

Example 7

The following date gives the number of aircraft accidents that occurred during the various days of a week. Find whether the accidents are uniformly distributed over the week.

Days:	Sun	Mon	Tue	Wed	Thu	Fri	Sat
No. of. accidents:	14	16	8	12	11	9	14

Solution:

The parameter of interest is to test the accidents are uniformly distributed.

a. The null hypothesis H_0: The accidents are uniformly distributed over the week.
   alternative hypothesis H_1 : The accidents are not uniformly distributed.
b. Level of significance: 5%

O	**E**	**O-E**	$\frac{(O-E)^2}{E}$
14	12	2	0.333
16	12	4	1.333
8	12	-4	1.333
12	12	0	0
11	12	-1	0.083
9	12	-3	0.75
14	12	2	0.333
		Total	4.165

degrees of freedom = n-1 = 7-1 = 6

Table value = 12.592

c. Test statistic $\chi^2 = \sum \frac{(O-E)^2}{E}$.

d. Total number of accidents = 84.

On the assumptions of H_0, the expected number of accidents on any day = $\frac{84}{7} = 12.$

e. Conclusion: |4.165| <12.592

So, we accept the null hypothesis H_0 at 5% level of significance.

∴ Thus, the accidents are uniformly distributed over the week.

Example 8

A sample analysis of examination results of 500 students was made. It was found that 220 students have failed, 170 have secured a third class, and 90 have secured a second class and the rest, a first class. So, do these figures support the general belief that the above categories are in the ration 4: 3: 2: 1 respectively?

Solution:

The variable of interest is the results in the four categories.

a. H_0 : The results in the four categories are in the ratio 4: 3: 2: 1.

H_1: The results in the four categories are in the ratio 4: 3: 2: 1

b. Level of significance: 5% degrees of freedom = n-1 = 4-1 = 3

Table value = 7.815

	O	**E**	$\boldsymbol{\frac{(O-E)^2}{E}}$
Failures	220	220	2.000
III	170	150	2.667
II	90	100	1.000
I	20	50	18.000
			23.667

c. Test statistic $\chi^2 = \sum \frac{(O-E)^2}{E} = 23.667$

d. **Conclusion:** |23.667| <7.815

So, we reject the null hypothesis H_0 at 5% level of significance.

Hence, the results of the four categories are not in the ration 4 : 3 : 2 : 1.

2.8 Conclusion:

A hypothesis is an educated guess about something in the world around us. Hypotheses are theoretical guesses based on limited knowledge; they need to be tested. Thus, hypothesis testing is a decision-making process for evaluating claims about a population. We use various statistical analysis to test hypotheses and answer research questions. In formal hypothesis testing, we test the null hypothesis and usually want to reject the null because rejection of the null indirectly supports the alternative hypothesis to the null, the one we deduce from theory as a tentative explanation. Thus, a hypothesis test mutually exclusive statements about a population to determine which statement is best supported by the sample data.

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3. John Rawls' "Reflective Equilibrium" A Methodology for Testing Hypotheses

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3.1 Abstract:

John Rawls theory of justice is a work dedicated toward the re-examination of the foundation of our thought system and of social and political institutions by subjecting them to the test and standard of truth and justice. Methodologically his system of thought, especially his idea of 'original position' yields a rigorous thought processes for rational reflection known as 'reflective equilibrium'. It is a method for testing principles and evaluating judgments by following certain reasonable restrictions in a hypothetical state of initial situations. Reflective equilibrium method not only exert the role of free people to their choice of principles to assigned rights, duties and benefits in social cooperation but also envision the possibility of social justice and well-ordered society through rational reflection. Rawls in the idea of 'veil of ignorance' aims to ensure transparency in the choice of these principles from personal inclinations and prejudices. This conceptual framework of the method of 'reflective equilibrium' is built-in to Rawls theory of justice.

3.2 Introduction:

John Rawls (1921-2002) theorization of justice starts as an enquiry into our basic assumption that asserts the primacy of justice and truth. His theory of justice asserts that truth and justice are uncompromising virtues in human activities and that they are inevitable for social justice and for the achievement of well-ordered society. Rawls theory of justice not only serve as an alternative to the doctrines of the classical Utilitarianism and Intuitionism conception of justice but also provide a methodical examination into our basic assumption of how we arrive to the agreement of a principles of justice in the initial situation. Rawls theory of justice basically is a work dedicated toward the re-examination of the foundation of our thought system and of social and political institutions by subjecting them to the test and standard of truth and justice. Similarly, methodologically his system of thought especially his idea of 'original position' yields a rigorous thought processes for rational reflection known as 'reflective equilibrium'. It is a method of testing principles and evaluating judgments by following certain reasonable restrictions in a hypothetical state of initial situations. More precisely, reflective equilibrium involves vigorous scrutiny of known principles about justice in order to arrive at commonly acceptable underlying principles through rational reflection. Achieving this state of equilibrium by rational reflection demands a disciplined and systematic evaluation of our judgements to these principles. There is basic assumption that these principles and our judgements about them are not certainare therefore subject to revisionin cases of discrepancies. Again, central to this rational inquiry is truth and justice. They therefore set the tone and standard for his inquiry and the development of his theory of justice.

3.3 Rawls' Hypothetical Edifice: 'Original Position':

Rawls conception of justice is moral and ideal in nature. It is moral since "Like moral conceptions in general, a conception of justice enunciates a set of rules or procedures by which ethical questions are to be answered and ethical disputes resolved" (Mikhail, 2011, p. 6). Rawls theory of justice is ideal since he seek a strict compliance to the principles of justice in order to derive principles of justice that would determine a well ordered society, a society that prioritizes equality and rational inquiry (Rawls, 1971).

Before we move further it is important to get ourselves familiarize some of the terminology that will be repeated used in the discussion of Rawls theory of justice. Some of these repeatedly occurring terms in Rawls' theory of justice include 'the state of nature' of social contract theory, Rawls' 'original position', 'veil of ignorance' 'justice as fairness' and 'reflective equilibrium'.

Rawls in his theory of justice interpret what is known in the traditionalist social contract theory as 'the state of nature'. By the idea of the state of nature, social contract theory explains and even justifies the formation of state. The state of nature, the theory explains is conditioned by perennial conflicts for resources and dominations of one group over another. According to Thomas Hobbes, this state where "all is against all" came to be resolved in the formation of the state which is based on certain contractual agreement. However, Rawls proposed 'original position' represents a new form of contract produced by people in the initial situation.

While Rawls' original position is a mental set-up devoid of social prejudices in order to achieve justice in the choices we make in the society, by 'reflective equilibrium' his attempt is to test the validity of this hypothetical situation in particular situations. In this hypothetical state of affairs, free people through rational reflection can choose the entitlements and rights of a society from a veil of ignorance. We arrive at 'veil of ignorance' by excluding the knowledge of those contingencies which sets men at odds and allows them to be guided by prejudices (p.19). In the original position free and rational people choose appropriate principles of justice from the veil of ignorance. Initial status quo better known for original position or initial situation aims to ensure that the fundamental agreement reached in the state are fair. This fact therefore yields the name 'justice as fairness'.

By his theory of justice, Rawls wanted to present a generalizing conception that would transcend social contract theories of Lock, Rousseau and Kant (Rawls, 1971). Social contract theories' conception of the state of nature is concerned with the assessment of 'how society may justly proceed' (Moseley, 2016, p. 110). According to social contract theories, the injustice reeked in society is mainly in the area of just distribution of resources and of opportunities.

In such society, welfare schemes meant to uplift the plight of the less unfortunate becomes contradictory to those who adhere to the claim of the inviolability of self-ownership, private property and privilege lifestyle. Since a person's right to welfare implies that someone ought to pay for it (Moseley, 2016). In this regard, Rawls 'Original Position' offers a novel conception of social contract theory. The importance of Rawls Original position therefore, lie in extending a novel approach to a State or a government that aims to strike a balance between these groups so as to establish fair and just society.

By his veil of ignorance, Rawls recommend a state whereby judgements and choices could be made without personal preferences or prejudices (Rawls, 1971). That is, the rights and entitlements are chosen from veil of ignorance that is, without prior knowledge of others' abilities or disabilities. Rawls imagined that in such society the worst-off would be taken care of 'as any person could find themselves in such a situation' (Moseley, 2016, p. 110).

3.4 Justification of the Original Position: Principles of Social Justice:

John Rawls theory of justice is distinct from all other conceptions of justice in that his theory is uniquely characterized by what is known as the 'original position'. He conceived the concept of the original position as the most favoured interpretation of the initial choice. In the initial stage of social cooperation, men are expected to chart out rules and regulations that would provide the foundation charter to the society. It is a society where everybody are expected to contribute and share in determining the standard of what is to be known as just and unjust. This comprises the choice principles of justice which would determine social burdens and benefits to all. He delineates the process of deciding the most favoured interpretation in the shared assumption about the initial situation. The original situation is a hypothetical situation that aims to test the validity of a particular situation by rational reflection. Thus, the original contract doesn't entertain a thought of entering a particular society or of setting up a particular government. Rather what's important here is determining 'the basic principles of justice for the basic structure of society.' Formation of the principle of justice is therefore the object of the original agreement. Every free and rational person prioritise the principle of justice reached by original agreement as it provides a proper channel whereby an individual as well group interests is advanced. Therefore, Rawls recognized these principles an initial position of equality as foundational for social cooperation (Rawls, 1971).

Rawls' conception of justice is different from all other conceptions of justice in that the principles of justice proposed from an original position specified by equality of rights in choice of principles. This is aimed toward resolving existing differences in the original situation for the assignment of right and duties in the basic institutions and distribution of benefits in social co-operation. Rawls theory of justice therefore aims to organize a well-ordered society by strictly adhering to the reasonable restrictions of justice by following a unique procedure to transcend disagreements about the principles in rational reflection and in the original situation. The distinctness of Rawls conception of justice leaves an open door for interpretation in the notion of arbitrary distinction and proper balance (Rawls, 1971).

While freedom community and efficiency are political values, Will Kymlicka in his Introduction to Contemporary Political Philosophy (2002) claim that 'justice is the standard by which we weigh the importance of other values' (Kymlicka, 2005, p. 168). According to him the virtue of justice is overarching for there are no other values to appeal to when policy is unjust. The concept of Justice to a well-ordered society is important as it adds due weight to other values.

3.5 Importance of Rawls Theory of Justice:

John Rawls theory of justice is narrowed down to focus on a special problem of justice that is the problem of 'the primary concept of justice' and or 'the basic structure of justice' (Mikhail, 2011, p. 7). His theory of justice is therefore embedded in social justice.

This theory of justice claims that 'justice is the first virtue of social institutions' (Rawls, 1971). In fact, his theory of justice is an important assertion of truth and justice. For him just as truth is to the system of thought, so is justice to social institutions.

A theory however elegant and economical must be rejected or revised if it is untrue; likewise, laws and institutions no matter how efficient and well-organized must be reformed or abolished if they are unjust (p.3).

Rawls firmly posits the validity of any theory to the standards of truth. Correspondingly the validity of laws and institutions are firmly subject to the standard of justice. Hence, according to Rawls, any theory, laws and institutions are subject to the test of truth and justice.

Having established the primacy and supremacy of truth and justice, Ralwsian theory of justice asserts the inviolability of individual's rights and freedom. He is the strongest opinion that "the rights secured by justice are not subject to political bargaining or to the calculas of social interests" (p.28). To him, justification of harm done to an individual (example: 'loss of freedom') at a pretext for general good is wrong by any standard of justice. Based on his theory Rawls built a strong case for individual rights. The fact is in a truly good and just society, equality amongst citizens is strictly observed (Rawls, 1971). Perhaps for this reason Marxist strongly believes that justice is not required in a truly good community. Thus, the appropriation of justice depends on certain but not all circumstances (Kymlicka, 2005).

Rawls conception of a well-ordered society is not the absence of conflict but is the recognition of a common principle adjudicated by a pubic sense of justice. Rawls sees a means of resolving the existing disagreements in the idea of just institutions. In a just institution, every judgement including assigning of rights and duties is not ruled by arbitrary distinction. Similarly, proper balance between competing claims is determined according to the rules of justice and for the best advantage of social life.

However, there are important factors that need to be kept in mind if rational deliberation is to succeed. We will need to know and deliberate on the following factors: Knowing 'the beliefs and interest of the parties', their relations to one another, the availability of alternative principles of justice from which they are to choose, and the procedure involved in this decision.

According to Rawls, disagreement in the original position persists in the form of social problems that exhibits lack of coordination, efficiency and stability. Therefore, in order to achieve a viable community 'some measure of agreement in the conceptions of justice' (p.6) must be reached. This includes fitting together of individual plans, needs and activities so that they do not conflict with other legitimate expectations. These plans must be executed not only for the achievement of social ends but in conformity with the concept of justice in a manner that is efficient and for the attainment of stability. Thus, Rawls social justice aims to provide a perfect coordination of social problems with the concept of justice.

All the while Rawls in his theory of justice asserts his firm conviction about the primacy of truth and justice, under exceptional case he seems to accommodate the contingent nature of justice. According to Rawls, this exceptional case includes the need to avoid greater injustice or certain form of injustice arises in the context of just-war (Rawls, 1971).

According to Rawls, not all conceptions of justice are equal. However, his justification of his conception of the theory of justice is based on the fact of the reasonableness of the theory. Since the primacy of justice and truth is uncompromisingly asserted by Rawls in his theory, he also opens a scope for the examination of convictions or other claims that are otherwise unsound. His theory of justice serves this end. By this theory, Rawls provides a method whereby we can assess and even interpret our claims.

3.6 Procedure to Enter Original Position: Reflective Equilibrium Method:

We can enter the original position, an imaginative original situation simply by following certain procedure. That is, we can argue for the principles of justice within the confinement of these restrictions. Reasonable restrictions that can be imposed on the discussion of the most appropriate principles include the following:

a. The reasonable restriction includes that 'no one should be advantaged or disadvantaged by natural fortune or social circumstances in the choice of the principles' (p.18). While the need is the choice of the principles, observance of equality in original position is a must.
b. Another reasonable restriction includes 'the impossibility to tailor principles' (p.18) in order to gain advantage in one's own case. This includes the need to insulate the choice of the principle of justice from personal self-interests, biases or prejudices, personal inclinations and aspirations. The purpose here is to rule out principles that would be irrelevant from the standpoint of justice.

Original position is characterized by equality amongst all parties. Conditions of equality thus range from equality in terms of choosing principles, making proposals and submitting reasons for acceptance. The purpose of these conditions is the assertion of 'equality as moral beings, as creature having a conception of good and capable of a sense of justice'.

Along with these requisite conditions, and the veil of ignorance combined we have John Rawls theory of justice. In the original position, every rational person willing to advance their interests would consent on equality of all parties.

In the next sector we will be concerned with justifying how the principles so chosen match our considered convictions of justice. We will justify a particular description of the original position by applying the principles to particular instances through rational reflection. This process of rational reflected can be assessed in the following ways:

a. **Rational Reflection Under Conditions of Assurance:** While applying these principles to particular instances it is important to consider if its application will yield the 'same judgement about the basic structure of society' that we use to draw intuitively. Rawls takes an instance from religious intolerance and racial discrimination in order to examine our convictions that are conclusively arrived at by rational reflection and impartial judgements. From the examination of these issues Rawls affirm that they are by dint of impartial judgements unjust. Such rational reflection that reflects impartial judgements, provisionally presume a fix points that are built in to any conception of justice.

b. **Rational Reflection Under Conditions of Doubt:** However, tainted by doubts we cannot assert the same conviction about the correct distribution of wealth and authority. Under this condition it is most viable to check an interpretation of the initial situation. So that later the capacity of its principles could accommodate our firmest convictions and to provide guidance where guidance is needed. In this regard, important to consider is the reliability of the principles to yield a resolution that can in turn be affirmed on reflection. This evaluation is particularly important when present judgements are doubted and when a resolution is given with hesitation.

The key to overcome doubts in rational reflection is by finding the most appropriate description of the initial situation. In below we find recommended steps to discover the best description of initial situation:

a. Describing initial situation that is inclusive of our shared presumptions and weak conditions.
b. Either checking to see if these conditions can yield a significant set of principles; or, 'we look for further premises equally reasonable to see if these principles match our considered convictions of justice' (p.19).
c. In case of discrepancies, we can either choose to modify the account of the initial situations or we can revise our existing judgements. Rawls do not believe in the certainty of principles and of our judgements about them since judgements are a provisional fixed point that is subject to revision.

Thus, 'reflective equilibrium' is the state of affairs we finally arrive at after having subjected our popular notions and considered judgements to the vigorous scrutiny of the conditions of what Rawls term the 'original positions' which is a 'contractual circumstances conditioned by certain reasonable restrictions. The term 'equilibrium' is a state of balance achieved between principles (we arrive at) and judgements (we make about these principles). Since the judgements we make are derived from following certain precepts, to that degree it is 'reflective' (Rawls, 1971).

3.7 Conclusion:

John Rawls' method of 'reflective equilibrium' is a conceptual framework built up on his conception of justice. This in turn is postulated by 'original position'- a hypothetical state of affairs formulated to test principles in particular situations so as to arrive at a viable and commonly accepted conception of justice which in turn could be used to achieve social justice and a well ordered society.

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4. The Elements Poignanting the Rationale of Research Problems in Educational Technology Researches

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4.1 Abstract:

Examination issues in a logical exploration are framed after a specific cycle. This cycle begins with characterizing an examination subject and changes into a particular exploration issue or theory. The point of this investigation was to look at the manner in which instructive innovation analysts recognize their examination issues. To this end, sources that instructive innovation scientists apply to and factors that influence instructive innovation analysts during the way toward characterizing research issue, and how instructive innovation specialist's slender examination problems were analyzed.

The exploration was done as a contextual analysis. Information were assembled from instructive tech-neology scientists by semi-organized meetings. Members were ten specialists who were doctoral stud-marks and employees from three distinct colleges. Information were exposed to content examination. Discoveries introduced under "Sources Used, Factors and Narrowing the Problem" topics related with characterizing research issue. Writing, singular components and Academic Exchange were the basic classes under these three subjects. Likewise, extent of the issue was distinguished as compelling regarding restricting the issue and identifying the issue. The aftereffects of the examination are relied upon to be valuable for instructive innovation scientists.

Keywords:

Educational Technology Research, Research Process, the Process of Defining Research Problems.

4.2 Introduction:

Logical exploration as a rule begins with having an issue, ability to take care of an issue or interest in a theme. Accordingly, each investigation begins with an examination issue and finishes with a report (Dunne, Pryor, and Yates, 2005). An examination issue can be related to various ways. They incorporate scientists every day beneficial experience (Maddux, 2003), issues looked in usage, requirement for testing speculations (Tomul, 2009) and suggestion raised by past investigations. Other than intriguing, researchable, reasonable and productive points, specialist's having adequate starter data and abilities about the subject and accessibility of related information influence meaning of exploration theme.

Furthermore, conversation of potential exploration points in logical functions assumes a significant part in characterizing the issue to be considered.

In the wake of settling on the exploration issue, the issue must be limited and examination addresses must be composed (Anderson, 1998). Numerous specialists bring up that characterizing the issue bears basic significance for the entire examination measure (Bryman, 2007). In this point it is essential to recognize the examination subject and exploration issue. Examination themes can be emerging from scientists' very own encounters and information picked up by the various investigations then again research issue characterizes the claim to fame about the subject. Subsequently research issues contribute the improvement of fascinating and critical hypotheses or testing speculations. Likewise, they legitimately impact the association with the writing and the exploration system.

There are a wide range of strategies with respect to issue characterizing measure in the writing. They incorporate alluding to the writing, contemporary practices, individual encounters and applying to different controls (Alter and Dennis, 2002). Among others, recognizing research holes is the most remarkable strategy. Such investigations are centered on three unique cases:

- Initially, as disputable things are recognized in the writing, examines are done to edify these things.
- Second, correlative examinations are done in connection with past investigations in the writing.
- Third, examines are done to distinguish and close the reasonable holes in situations where hypothetical examinations are finished yet not executed at this point (McMillan and Schumacher, 2010).

Analysts think in connection with characterizing the exploration issue that basic reasoning is expected to discover contemporary and new issues under conditions (Maddux, 2003). This recommendation could direct analysts occupied with instructive innovation, which is multidisciplinary and influenced from mechanical upgrades. The writing presents numerous investigations on portraying research patterns in instructive innovation. Those models give important data about exploration subjects considered both before and today. In any case, Liu (2008) contends that in connection with instructive innovation examines drifts alone would not be valuable for characterizing research issues, subsequently those instruments can't totally react to prerequisites of instructive innovation. To represent, Reeves (2000) advances three primary issues with respect to instructive innovations research: scientists can't separate fundamental and applied explores, investigates in this are not sufficient, writing audit and meta-examination isn't palatable and they are not managing enough for analysts. Additionally, inferable from the way that instructive innovation has a wide inclusion, it is applied and utilized in numerous territories, alluding to various scientist viewpoints will enable youthful analysts to improve their perspective. These investigations in the writing show that the way toward characterizing research issue in instructive innovation merits as much consideration as different zones. The point of this examination is to look at the manner in which instructive innovation scientists recognize their exploration subjects and issues. Especially, answer is looked for the accompanying examination questions.

- What sources instructive innovation specialists apply during the way toward characterizing research issue?
- What variables influence instructive innovation scientists during the way toward characterizing research issue?
- How do instructive innovation specialists limited an examination issue?

4.2.1 Research Model:

The exploration was done as a contextual investigation. This approach was chosen so as to profoundly inspect the encounters of instructive innovation scientists related with characterizing research issues and discover factors that rule in this cycle.

4.2.2 Members:

The members of the investigation were doctoral understudies and employees in the zone of instructive innovation. Purposive examining technique was utilized so as to choose members. In this way, by utilizing most extreme variety examining doctoral understudies and employees in the territory of instructive innovation from three unique colleges were remembered for the investigation. Members were ten specialists who were individuals from Computer Education and Instructional Technology (CEIT) office in Turkey, coded as K1, K2, K3, K4, K5, K6, K7, K8, K9 and K10.

4.2.3 Information Collection:

Semi-organized meeting convention was utilized as an information assortment instrument. With the assistance of this convention information were accumulated about the members' cycle of characterizing research issues. This convention contains five inquiries so as to uncover out the way toward characterizing research issues of members. The focal point of inquiries was the means by which to characterize and restrict the issues.

4.2.4 Information Analysis:

Meetings caught with a voice recorder and deciphered. By taking examination issues of study into thought information were broke down by utilizing content investigation. In this cycle above all else information were conceptualized; at that point as per decided ideas information masterminded and the best subjects that clarified information were resolved.

4.2.5 Legitimacy and Reliability:

To guarantee the reliability discoveries were inspected by various specialists and master feelings were taken in the exploration cycle.

For adaptability, purposive examining strategy were chosen, subjects and codes were introduced by direct citations taken from members. For likeness, all records were kept inspected by various analysts. In the exploration cycle peer survey were utilized and codes were examined by an alternate scientist.

4.2.6 Results:

In this segment, aftereffects of breaking down exploration discoveries and techniques applied for characterizing research issues are introduced under subjects "Sources, Factors and Limiting the Problem". Inscriptions and topics with respect to every one of the exploration issues are introduced in tables.

4.2.7 Sources Used:

In this examination, specialists' conclusions with respect to instruments and strategies applied while characterizing issue are explored. Gathered information were coded and introduced in classes. The sources applied in issue characterizing measure are given in four classes as "Writing, Academic Exchange, Area of Study and Individual Factors".

4.2.8 Variables:

Additionally, the elements influencing specialists in characterizing issues are remembered for this investigation. Despite the fact that review discoveries resemble the other the same the sources utilized, this subject additionally brought about the classification "Extent of the issue". Suppositions acquired under elements are given in four classes as "Extent of the Problem, Literature, Academic Exchange and Individual Factors".

4.2.9 Restricting the Problem:

In this part, scientists' perspectives with respect to how to restrict research issues are given. Their perspectives are introduced under five classifications as "Exploration technique, Literature, Academic Exchange, Individual Factors and Scope of the Problem".

4.2.10 Discussion:

This examination explores the cycle of instructive innovation specialists' characterizing logical exploration issues in the light of subjects, for example, assets utilized, factors influencing the cycle and restricting of the issue. It was discovered that specialists apply to writing as a significant hotspot for characterizing research issues. Likewise, they use writing at an impressive degree for characterizing and restricting the issue. Bradley (2001) and Shugan (2003) found that writing survey assumes a significant part in characterizing the exploration issue. Different investigations uncover that writing helps specialists in characterizing research issues frequently. Alluding to writing may incorporate examining issues that are not explained at this point, filling in the spaces and utilization of hypothetical information. Frequently utilization of writing may be disclosed with its ease to utilize, not being dubious, being a sheltered way, being perceived and being upheld by research organizations.

The discoveries show that analysts apply to scholastic sharing during characterizing of the examination issue and accordingly they allude to the mutual things while restricting the issue. A portion of the members study PhD. By scholarly sharing, they likewise mean meetings with their scholastic counselors.

The entirety of the members, especially those in PhD, as often as possible experience scholarly sharing by methods for looking for master and friend assessments. Significant outcomes in the writing additionally uphold this discovering. For instance, Bostancı and Yüksel (2005) in their investigation about characterizing the exploration issue bring up that scholastics should don't hesitate to apply to scholarly individuals and their experience.

As indicated by Bradley (2001), it is basic that specialists scrutinize each other's works for both creating basic reasoning abilities and interfacing hypothesis with training.

In a comparable vein, Kraut, Egido, and Galagher (1988) state that science is a social cycle past considering researchers to be people occupied with instruments and apparatuses in labs and examine the pretended by social communication in advancing logical examinations. In this specific circumstance, they likewise notice the impact of actual closeness on improving participation among specialists and the possibilities innovation bears for empowering removed scientists to work together. In our investigation, a portion of the members expressed that they trade contemporary materials with their partners through web for characterizing the issue. To this end, one member stays aware of scholarly organizations, for example, conversation records, discussions and virtual foundation of colleges in connection with her/his field to characterize research issues.

The examination exhibits that scientists are guided by such close to home issues as time, working climate, analyst ability and cost in settling on and restricting the issue. Similarly, Aslam and Emmanuel (2010) put out that time and cost are among factors that ought to be considered in characterizing research issues. As indicated by Fraenkel and Wallen (2003), a decent examination issue must be researchable inside a specific measure of time with a specific measure of exertion. Likewise, as indicated by our examination, analysts' territories of interest and capacity, proficient experience, other experience and specialized topic, relating to singular elements, are compelling in characterizing research issues.

Under assessment of acquired topics with singular components, in regard of trying specialized topic, instructive innovation analysts originating from different fields can coordinate their control with instructive innovation. Likewise Alter and Dennis (2002) recommend that examination issues can be characterized by alluding to different orders. Looking from this point of view, different foundation in issue characterizing cycle would definitely make logical examination more proficient and higher caliber and assume a significant function in raising qualified labor force, creating information and serving to the network (Erdem, 2006).

We likewise discovered that members characterize research issues in relationship with certain issues they face in their exercises or workplaces. Additionally, Tomul (2009) focuses solid issues looked in execution as a strategy for characterizing research issues. In this specific circumstance, specialists noticed that they especially study matters and genuine issues in their fields. It was added that the field has a wide scope of subjects in issue characterizing measure for what it's worth about innovation.

For instance, Erdoğmuş and Çağıltay (2009) propose that instructive innovation has such a huge inclusion that it is executed and utilized in numerous regions. Despite the fact that essentially steady of the discoveries, Maddux (2003) brings up that genuine issues can be a wellspring of exploration issues. The members expressed that they additionally are motivated by instances of coordination of current advancements with schooling.

4.3 End-Note:

This investigation distinguishes how the way toward characterizing research issues in instructive innovation happens. Henceforth, it is felt that our investigation could help discover what analysts consider in characterizing research issue. Then again, as this investigation is done with a restricted example gathering, further examinations should be possible to clarify research issues better.

The way toward characterizing the exploration issue is examined under three topics as sources applied to, elements and restricting the issue in the light of discoveries. Point by point conversation of the three topics gives different classifications, for example, writing, singular variables and scholarly trade under the entirety of the three subjects.

In this manner, it very well may be said that discovered classes go with the cycle of issue characterizing. Aside from these, it is discovered that applications impossible to miss to instructive innovation are utilized in characterizing research issues.

At the end of the day, the region of study is persuasive at this stage. Concerning the realities influencing specialists in settling on the issue, extent of the issue appears to be remarkable other than the three regular classes.

In this specific situation, it was discovered that contemporary, real and promising themes become persuasive for analysts' settling on choice. With respect to narrowing down of the issue; research technique, test choice, research period and dependability and legitimacy considers manage scientists other than the extent of the issue contemplated.

As an end, advancing the exploration issue is the main part of logical examination. It is underlined that characterizing of the exploration issue is persuasive all in all examination; along these lines, choice can be made on the best way to do the exploration and what strategy will be utilized at that point.

At this stage, it is believed that examination techniques are simple apparatuses, and these instruments can be utilized just if there are solid points (Reeves, 2000). Withdrawing from the significance of legitimate ID of the examination issue for the remainder of the logical cycle, following suggestions can be made:

- At postgraduate level, further courses must be offered with respect to the significance of writing and survey of writing.
- Steady contact ought to be kept with researchers so data and experience can be traded, and scholastic functions, for example, discussion, gathering, gatherings, and so forth ought to be followed for new chances. Besides, postgraduate understudies ought to be urged to all scholarly exercises.
- Consistent and proficient relations ought to be set up between executing bodies at public level and researchers so as to take care of contemporary issues and propose powerful outcomes.
- Study points should be researchable and plausible contemplating time and specialization necessities. While characterizing the examination theme and issues, singular factors, for example, territories of interest and specialization ought to be thought of.
- Chosen research issues should be contemporary, valid and gainful for the order, and patterns in the control ought to be followed.
- Analysts particularly in instructive innovation, as a quickly changing and creating region, ought to have a guide for distinguishing research issues.
- Specialists can frame their examination gatherings and gap errands, so they can stay aware of upgrades in this day and age since things change so rapidly. Additionally, they can share their insight and legitimize their examinations, and reprimand each other's investigations.

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5. Reliability and Validity in a Research Study

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5.1 Introduction:

In this chapter you will learn about:

- Reliability Vs Validity
- The Concept of Reliability
- Types of Reliability
- The concept of Validity
- Types of Validity
- How to ensure validity and reliability in your research
- Reliability and Validity in a thesis

Keywords: Reliability, validity, tests, instrument, measurement, research, consistency, construct validity, content validity, face validity.

5.2 Reliability Vs Validity:

In every research, it is important for us to attempt to establish the quality of results. The concepts of Reliability and validity are used to extract the research quality. Combinedly they evaluate the best way of measuring tests and techniques result. They provide the measurement consistency and accuracy, i.e; Reliability measure a consistency and Validity measures an accuracy. It is used especially in quantitative research to design research methodology and its analysis.

Reliability Vs Validity		
Basis	**Reliability**	**Validity**
Meaning	The extent at which reproduction of the results can be done in same conditions.	The extent at which the measurement of results can be done when what they are supposed to measure.

Reliability Vs Validity		
Basis	**Reliability**	**Validity**
Assess	By going through the result consistency within a time period, with different observers, and throughout the parts of the test itself.	By going through the wellness of the correspondence of results in comparison to theories and results of others concept.
Relatedness	Reliable measurement is not always valid.	But a valid measurement is generally reliable.

The concepts of reliability and validity:

Both Reliability and validity are related to each other, but they mean different things. A measurement can be reliable without being valid. However, if a measurement is valid, it is usually also reliable.

5.3 The Concept of Reliability:

We use the word ‘reliable’ very often in our lives. When we say that a person is reliable, what do we mean? We infer that s/he is dependable, consistent, predictable, stable and honest. The concept of reliability in relation to a research instrument has a similar meaning: if a research tool is consistent and stable, hence predictable and accurate, it is said to be reliable. The greater the degree of consistency and stability in an instrument, the greater its reliability. Therefore, ‘a scale or test is reliable to the extent that repeat measurements made by it under constant conditions will give the same result’ (Moser & Kalton 1989: 353).

Reliability refers to how consistently a method measure something. If the same result can be consistently achieved by using the same methods under the same circumstances, the measurement is considered reliable.

The concept of reliability can be looked at from two sides:

a. How reliable is an instrument?
b. How unreliable is it?

The first question focuses on the ability of an instrument to produce consistent measurements. When you collect the same set of information more than once using the same instrument and get the same or similar results under the same or similar conditions, an instrument is considered to be reliable.

The second question focuses on the degree of inconsistency in the measurements made by an instrument – that is, the extent of difference in the measurements when you collect the same set of information more than once, using the same instrument under the same or similar conditions. Hence, the degree of inconsistency in the different measurements is an indication of the extent of its inaccuracy. This ‘error’ is a reflection of an instrument’s unreliability. Therefore, reliability is the degree of accuracy or precision in the measurements made by a research instrument. The lower the degree of ‘error’ in an instrument, the higher the reliability.

Reliability tells you how consistently a method measure something. When you apply the same method to the same sample under the same conditions, you should get the same results. If not, the method of measurement may be unreliable.

5.4 Types of Reliability:

Types of reliability can be estimated through various statistical methods. There are a number of ways of determining the reliability of an instrument and these can be classified as either external or internal consistency procedures.

Types of Reliability	
Test-retest	Measures the consistency of the same test over time.
Interrater	Measures the consistency of the same test conducted by different researchers
Parallel forms	Measures the consistency of two different tests that measures the same thing.
Internal consistency	Measures the consistency of the individual items by using a multi-item test.

	What does it assess?	**Example**
Test-retest	The consistency of a measure **across time**: do you get the same results when you repeat the measurement?	A group of participants complete a questionnaire designed to measure personality traits. If they repeat the questionnaire days, weeks or months apart and give the same answers, this indicates high test-retest reliability.
Interrater	The consistency of a measure **across raters or observers**: do you get the same results when different people conduct the same measurement?	Based on an assessment criteria checklist, five examiners submit substantially different results for the same student project. This indicates that the assessment checklist has low inter-rater reliability (for example, because the criteria are too subjective).
Internal consistency	The consistency of **the measurement itself**: do you get the same results from different parts of a test that are designed to measure the same thing?	You design a questionnaire to measure self-esteem. If you randomly split the results into two halves, there should be a strong correlation between the two sets of results. If the two results are very different, this indicates low internal consistency.

5.4.1 Test-Retest Reliability:

Test-retest reliability measures the consistency of results when you repeat the same test on the same sample at a different point in time. You use it when you are measuring something that you expect to stay constant in your sample.

Improving test-retest reliability

- When designing tests or questionnaires, try to formulate questions, statements and tasks in a way that won't be influenced by the mood or concentration of participants.
- When planning your methods of data collection, try to minimize the influence of external factors, and make sure all samples are tested under the same conditions.
- Remember that changes can be expected to occur in the participants over time and take these into account.

5.4.2 Interrater Reliability:

Interrater Reliability (also called interobserver reliability) measures the degree of agreement between different people observing or assessing the same thing. You use it when data is collected by researchers assigning ratings, scores or categories to one or more variables.

Improving interrater reliability

- Clearly define your variables and the methods that will be used to measure them.
- Develop detailed, objective criteria for how the variables will be rated, counted or categorized.
- If multiple researchers are involved, ensure that they all have exactly the same information and training.

5.4.3 Parallel Forms Reliability:

Parallel forms reliability measures the correlation between two equivalent versions of a test. You use it when you have two different assessment tools or sets of questions designed to measure the same thing.

Improving parallel forms reliability

- Ensure that all questions or test items are based on the same theory and formulated to measure the same thing.

5.4.4 Internal Consistency:

Internal consistency assesses the correlation between multiple items in a test that are intended to measure the same construct. Internal consistency can be calculated without repeating the test or involving other researchers, so it's a good way of assessing reliability when you only have one data set.

Improving internal consistency

- Take care when devising questions or measures: those intended to reflect the same concept should be based on the same theory and carefully formulated.

5.5 The Concept of Validity:

Validity refers to how accurately a method measures what it is intended to measure. If research has high validity, that means it produces results that correspond to real properties, characteristics, and variations in the physical or social world.

As inaccuracies can be introduced into a study at any stage, the concept of validity can be applied to the research process as a whole or to any of its steps: study design, sampling strategy, conclusions drawn, the statistical procedures applied or the measurement procedures used.

Broadly, there are two perspectives on validity:

a. Is the research investigation providing answers to the research questions for which it was undertaken?
b. If so, is it providing these answers using appropriate methods and procedures?

High reliability is one indicator that a measurement is valid. If a method is not reliable, it probably isn't valid.

In terms of measurement procedures, therefore, validity is the ability of an instrument to measure what it is designed to measure: 'Validity is defined as the degree to which the researcher has measured what he has set out to measure' (Smith 1991: 106).

According to Kerlinger, 'the commonest definition of validity is epitomised by the question: Are we measuring what we think we are measuring?' (1973: 457). Babbie writes, 'validity refers to the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration' (1989: 133).

However, reliability on its own is not enough to ensure validity. Even if a test is reliable, it may not accurately reflect the real situation.

Validity is harder to assess than reliability, but it is even more important. To obtain useful results, the methods you use to collect your data must be valid: the research must be measuring what it claims to measure. This ensures that your discussion of the data and the conclusions you draw are also valid.

5.6 Types of Validity:

The validity of a measurement can be estimated based on three main types of evidence. Each type can be evaluated through expert judgement or statistical methods.

Types of Validity	
Construct	Measures the concept of existing theory and knowledge
Content	Measures the concept from all aspects
Face	Measures the concept of aim of the test
Criterion	Measures the concept from other valid measures

Type of validity	What does it assess?	Example
Construct	The adherence of a measure to **existing theory and knowledge** of the concept being measured.	A self-esteem questionnaire could be assessed by measuring other traits known or assumed to be related to the concept of self-esteem (such as social skills and optimism). Strong correlation between the scores for self-esteem and associated traits would indicate high construct validity.
Content	The extent to which the measurement **covers all aspects** of the concept being measured.	A test that aims to measure a class of students' level of Spanish contains reading, writing and speaking components, but no listening component. Experts agree that listening comprehension is an essential aspect of language ability, so the test lacks content validity for measuring the overall level of ability in Spanish.
Face	The extent to which the result of a measurement has logical link between items and objectives.	A study is conducted to identify health injuries due to smoking. If the results predict that smoking is injurious to health, this will indicate the obvious link between the conditions.
Criterion	The extent to which the result of a measure corresponds to **other valid measures** of the same concept.	A survey is conducted to measure the political opinions of voters in a region. If the results accurately predict the later outcome of an election in that region, this indicates that the survey has high criterion validity.

5.6.1. Construct Validity:

Construct validity evaluates whether a measurement tool really represents the thing we are interested in measuring. It's central to establishing the overall validity of a method.

A construct refers to a concept or characteristic that can't be directly observed but can be measured by observing other indicators that are associated with it. It is a more sophisticated technique for establishing the validity of an instrument.

It is based upon statistical procedures. It is determined by ascertaining the contribution of each construct to the total variance observed in a phenomenon.

Constructs can be characteristics of individuals, such as intelligence, obesity, job satisfaction, or depression; they can also be broader concepts applied to organizations or social groups, such as gender equality, corporate social responsibility, or freedom of speech. One of the main disadvantages of construct validity is that you need to know about the required statistical procedures. The other types of validity described below can all be considered as forms of evidence for construct validity.

5.6.2 Content Validity:

Content validity assesses whether a test is representative of all aspects of the construct. To produce valid results, the content of a test, survey or measurement method must cover all relevant parts of the subject it aims to measure. If some aspects are missing from the measurement (or if irrelevant aspects are included), the validity is threatened.

The judgement that an instrument is measuring what it is supposed to is primarily based upon the logical link between the questions and the objectives of the study. Hence, one of the main advantages of this type of validity is that it is easy to apply. Each question or item on the research instrument must have a logical link with an objective. It is important that the items and questions cover the full range of the issue or attitude being measured. Assessment of the items of an instrument in this respect is called content validity. In addition, the coverage of the issue or attitude should be balanced; that is, each aspect should have similar and adequate representation in the questions or items. Content validity is also judged on the basis of the extent to which statements or questions represent the issue they are supposed to measure, as judged by you as a researcher, your readership and experts in the field.

5.6.3 Face Validity:

Face validity considers how suitable the content of a test seems to be on the surface. It’s similar to content validity, but face validity is a more informal and subjective assessment. As face validity is a subjective measure, it’s often considered the weakest form of validity. However, it can be useful in the initial stages of developing a method. The judgement that an instrument is measuring what it is supposed to is primarily based upon the logical link between the questions and the objectives of the study. Hence, one of the main advantages of this type of validity is that it is easy to apply. Each question or item on the research instrument must have a logical link with an objective. Establishment of this link is called face validity.

5.6.4 Criterion Validity:

Criterion validity evaluates how closely the results of your test correspond to the results of a different test.

The criterion is an external measurement of the same thing. It is usually an established or widely-used test that is already considered valid. To evaluate criterion validity, you calculate the correlation between the results of your measurement and the results of the criterion measurement. If there is a high correlation, this gives a good indication that your test is measuring what it intends to measure. ‘In situations where a scale is developed as an indicator of some observable criterion, the scale’s validity can be investigated by seeing how good an indicator it is’ (Moser & Kalton 1989: 356).

How to ensure validity and reliability in your research

The reliability and validity of your results depends on creating a strong research design, choosing appropriate methods and samples, and conducting the research carefully and consistently.

Ensuring validity

If you use scores or ratings to measure variations in something (such as psychological traits, levels of ability or physical properties), it's important that your results reflect the real variations as accurately as possible. Validity should be considered in the very earliest stages of your research, when you decide how you will collect your data.

- Choose appropriate methods of measurement.

Ensure that your method and measurement technique are high quality and targeted to measure exactly what you want to know. They should be thoroughly researched and based on existing knowledge. For example, to collect data on a personality trait, you could use a standardized questionnaire that is considered reliable and valid. If you develop your own questionnaire, it should be based on established theory or findings of previous studies, and the questions should be carefully and precisely worded.

- Use appropriate sampling methods to select your subjects.

To produce valid generalizable results, clearly define the population you are researching (e.g., people from a specific age range, geographical location, or profession). Ensure that you have enough participants and that they are representative of the population.

Ensuring Reliability:

Reliability should be considered throughout the data collection process. When you use a tool or technique to collect data, it's important that the results are precise, stable and reproducible.

- Apply your methods consistently.

Plan your method carefully to make sure you carry out the same steps in the same way for each measurement. This is especially important if multiple researchers are involved.

For example, if you are conducting interviews or observations, clearly define how specific behaviours or responses will be counted, and make sure questions are phrased the same way each time.

- Standardize the conditions of your research.

When you collect your data, keep the circumstances as consistent as possible to reduce the influence of external factors that might create variation in the results.

For example, in an experimental setup, make sure all participants are given the same information and tested under the same conditions.

Where to write about reliability and validity in a thesis It's appropriate to discuss reliability and validity in various sections of your thesis or dissertation. Showing that you have taken them into account in planning your research and interpreting the results makes your work more credible and trustworthy.

Reliability and validity in a thesis	
Section	**Discuss**
Literature review	What have other researchers done to devise and improve methods that are reliable and valid?
Methodology	How did you plan your research to ensure reliability and validity of the measures used? This includes the chosen sample set and size, sample preparation, external conditions and measuring techniques.
Results	If you calculate reliability and validity, state these values alongside your main results.
Discussion	This is the moment to talk about how reliable and valid your results actually were. Were they consistent, and did they reflect true values? If not, why not?
Conclusion	If reliability and validity were a big problem for your findings, it might be helpful to mention this here.

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