RESEARCH METHODOLOGY

(A Guide for Scholars)

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CONTENT

1. Hypothesis

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1.1 Introduction:

"…………hypotheses are powerful tools for the advancement of knowledge…… This is too important that we ensure to say that there could be no science in any complete sense without hypothesis." – **Kerlinger.**

Any Scientific investigation starts with the statements of the solvable problem. When the problem has been started, a tentative solution in the form of a testable proposition is offered by the investigation. This testable proposition is called a Hypothesis. Hypothesis (i.e. hypo + thesis) means a rational viewpoints i.e., a theory which is still to be reasoned and tested.

Thus a theory which if formulated for the study of the facts and to examine the validity of the theory. Therefore, a hypothesis is nothing but a suggested testable answer to a problem.

In other words, we may say that – "A hypothesis is a testable relationship between two or more that two variables.

1.1.1 Definitions:

A hypothesis involves observation, reflextion, deduction and verifications. It has been defined as any supposition which we make (either without actual evidence or an evidence a roundly insufficient) in order to endeavor to deduce conclusion in accordance with facts which are known to be real, under the idea that if the conclusions to which hypothesis leaps are known truths, the hypothesis itself either must be or at least likely to be, true".

According to Lundberg – "A hypothesis is a tentative generalization the validity of which remains to be tested."

Me Guigan (1990) has defined hypothesis as, "a testable statement of a potential relationship between two or more variables."

Kelinger (1973) has defined as, "a conjectural statement of the relation between two or more variables William H. George has defined that – "The hypothesis actually emerge from the theory.

It is a generalization drawn from the theory itself and when it has been tested and found correct it becomes a part of the theory itself. Thus theory itself in its early form is only a hypothesis and the two are interdependent upon each other."

On the basis of these definitions two points are clear:

- Hypothesis is a testable statement, which means that it displays the relationship between those variables which are measurable or potentially measurable.
- A hypothesis exhibits either a general or specific relationship between variables.

1.2 Sources of Hypothesis:

According to Goode and Hatt following are the sources of a hypothesis:

a. General Culture: The general pattern of culture facilitates in formulating a hypothesis, and also to guide its trend. Culture having immense influence upon the thinking process of people a hypothesis may be evolved to test one or more of these ideas. The metaphysical basis in Indian culture and these metaphysical ideas may form a suitable basis of hypothesis of a social research.

b. Scientific Theory: A theory provides the basis of what has been discovered to be correct. The knowledge of theory enables one to form further generalizations and such corollaries or generalization form the part of hypothesis.

c. Analogies: There are situations when a hypothesis is formed from the analogy. The step taken is find out a similarity between two phenomena. The next step is to form a hypothesis to test whether the two phenomena or similar in any other respect. According to

Prof. Julian Huxley,, the casual observation in nature or frame work of another sciences may be a fertile source of hypothesis.

d. Personal Experience of the Researcher: Goode and Hatt feel that not only do culture, science and analogy effect the formation of hypothesis the way in which an individual reacts to each of these is also a factor in the statement of hypothesis. Sometimes the facts are there, but a right individual assess it in right perspective and formulates a hypothesis.

Importance of Hypothesis in Scientific Research: The importance of hypothesis lies in its indispensability for any research. Hypothesis, forms the basis of the scientific research. In the absence of a clear, simple and scientific hypothesis it would defeat the very purpose of research as in such a situation a lot of time and labour is wanted in fruitless research. The advantages of hypothesis in any scientific enquiry are briefly mentioned below:

a. It gives point to enquiry. Hypothesis makes the research more specific and to the point and lead towards the destination. It is opined that „in the absence of hypothesis the researcher is like a sailor on the vast unchartered sea without compass or rudder. Hypothesis provides direction to research.

b. It helps deciding the direction of research. Since research aims at discovery of new facts, it must be proceeded in a right direction to achieve the goal. Hypothesis provides that direction and thus a scientist with proper hypothesis can arrive at right conclusion in the long run.

c. It helps in selecting required facts. A researcher comes across a number of factors while studying and he must confine himself to the study only those factors that are relevant to our study. This necessitates the process of delimiting and sigling out pertinent facts and hypothesis is essential for the purpose. **P. V. Young** has rightly remarked – "The use of hypothesis prevents a blind search and indiscriminate gathering of masses of data which may later prove irrelevant to the problem under study."

d. It enable the researchers to draw specific conclusions. Hypothesis helps in coming to particular and well defined conclusions. In the opinion of Goode and Hatt: "Without hypothesis the research is unfocussed, a ramdom empirical wandering. The results cannot be stated as facts with clear meaning. Hypothesis is necessary link between theory and investigations, which lead to discovery of addition to knowledge."

1.3 Formulation of Hypothesis:

It is difficult to tell precisely how a scientist formulates a hypothesis because. The process of formulation itself it vague and idiosyncratic. Goode & Hatt (1952) have pointed out three major possible difficulties in formulation of a good research hypothesis.

- The Absence of knowledge of a theoretical framework is a major difficulty in formulating a good research hypothesis. If detailed theoretical evidences are not available or if the investigator is not aware of the availability of those theoretical evidences, a research hypothesis cannot be formulated.
- When the investigator lacks the ability to utilize the knowledge of the theoretical framework, a hypothesis cannot be formulated.
- When the investigator is not aware of the important scientific research techniques, he will not be able to frame a good research hypothesis.

Despite these difficulties, the investigator attempts in his research to formulate a hypothesis. Usually the hypothesis is derived from the problem statement. The hypothesis should be formulated in a positive and substantive form before date is collected. In some cases additional hypotheses may be formulated after data has been collected, but they should be tested on a new set of data and not on the old set which has suggested it. The formulation of a hypothesis is a creative task and involves a lot of thinking, imagination and the like. Reichenbach (1938) has made a distinction between the two process found commonly in any hypothesis-formulation task. One is the *context of discovery* and another is the *context of justification.* The manner or the process through which a scientist arrives at a hypothesis illustrates the context of discovery, and the presentation of evidence or proof in support of the truth of the hypothesis illustrates the context of justification. A scientist is concerned more with the context of justification in the development of a hypothesis. He never puts his ideas or thoughts as they nakedly occur in the formulation of a hypothesis. Rather, he logically reconstructs his ideas and thoughts and draws some justifiable inferences from those ideas and thoughts. He never cares to relate how he actually arrived at a hypothesis. He does not say, for example, that while he was shaving, this particular hypothesis occurred to him. He, usually arrives at a hypothesis by the rational reconstruction of thoughts. When a scientist reconstructs his thoughts and communicates them in the form of a hypothesis to others, he uses the context of justification.

When he arrives at a hypothesis, he extensively as well as intensively surveys a mass of data, abstracts them, tries to find out similarities among the abstracted data and finally makes a generalization or deduces a proposition in the form of a hypothesis.

For example, consider the following situation in Pavlovian conditioning. A bell is sound and immediately after that meant powder is presented to a dog. The dog starts salivating. After a number of presentations of the bell and food, the dog salivates at the mere presentation of the sound of the bell. In such a situation the experimenter observes that all the instances of salivation made in each trial are similar to each other and hence, they are abstracted by him as belonging to one general class of the salivation response. Likewise, the sound of the bell presented in each trial is seen by him as forming one general class because all the sounds of the bell are similar enough to form a class. Thus the scientist uses classification for distributing a mass of data into a smaller number of categories so that they can be effectively handled. Next, he tries to find out the relationship between the classified data so that a hypothesis can be formulated. For example, the experimenter may now formulate the hypothesis: After so many repetitions of the bell and food, the dog will eventually respond to the mere sound of the bell.

The above example, illustrates the typical process through which a scientist, at least a behavioral scientist, proceeds before arriving at a hypothesis. However, there is no dearth of scientists who proceed in a haphazard way in formulating a hypothesis.

1.4 Functions of Hypothesis:

A hypothesis does the following major functions:

A. Hypothesis test the various theories: In behavioural research the researcher develops a theory to account for some phenomenon and then, he devises a means whereby they theory can be tested. He seldom tests the theory directly. Most of the time he conducts tests of hypotheses that have been generated and derived from that theory. If the hypothesis test out as specified by the researcher, it is said that his theory is supported in part. Thus one of the major functions of hypothesis is to make possible to test theories. Thus in this light an alternative definition of a hypothesis can be the statement of theory in a testable form. All statements of theory in testable form can be called hypothesis.

B. Hypotheses suggest the various theories: In behavioural research it is often found that some hypothesis are not associated with any particular theory. It is just possible that as a result of some hypothesis, a theory may eventually be constructed. Therefore, another function of hypothesis is to suggest theories that may account for some event.

Although it is a common practice that the researcher proceeds from theory to hypothesis, occasionally the reverse is true. The researcher may have some idea about why a given phenomenon occurs and he may hypothesize a number of things that relate to it. He may find that some hypotheses have greater potential than others for explaining the event or particular behavior, and a result, he may construct a logical system of propositions, assumption and definitions linking his explanation to the event. In other words, it can be said that he have devised a theory.

C. Hypotheses ten to describe social phenomena: A hypothesis also does a descriptive function. When a researcher tests a hypothesis empirically, it tells him something about the phenomenon it's associated with. If the hypothesis is supported then his information about the phenomenon increases. When the hypotheses are refuted, the test tells us something about the phenomenon the researcher did not now before. The accumulation of information as a result of the hypothesis testing that way reduces the amount of ignorance of the researchers.

Apart from these primary functions, hypotheses also have some important secondary functions. In fact, testing hypotheses tend to refute some „common sense" notion about the behavior of the organism, raise questions about the explanations we presently use to account for things and also tend to alter our orientation towards the environment to one degree or another. Besides these, as a result of testing certain hypotheses, social policy may be formulated in communities, delinquents and offenders may be treated differently, teaching methods may be modified and improved, solutions to various kinds of problems may be suggested and penal institutions may be redesigned and revamped.

1.5 Types of Hypothesis:

On the basis of degree of generality, research can be divided into two types:

- Universal hypothesis
- Existential hypothesis

A universal hypothesis is one in which the stated relationship holds good for all the levels or values of variables which are specified for all time at all places. "Adequate level of light increases reading efficiency" is an example of universal hypothesis.

Existential hypothesis is one which states that the relationship stated holds good for at least one particular case. For example, "there is at least one schizophrenic who does not have either delusion or hallucination" is an example of existential hypothesis. Of those two types of hypotheses, the universal hypothesis is preferred because such a hypothesis has a greater predicative power that the existential hypothesis. As we know hypothesis is a formally stated expectation about a behavior that defines the purpose and goals of the study being conducted. Based upon the goals of explaining and controlling the causes of behavior, there are two types of hypothesis:

- Causal hypothesis
- Descriptive hypothesis

A causal hypothesis postulates a particular causal influence or behavior. In other words, it tentatively explains a particular influence on. Or a cause for, a particular behavior. For example, if the researcher hypothesizes that boring contents of commercial advertisements is the cause of channel changing by TV viewers it becomes the example of causal hypothesis. Although it is a fact that boring contents may not be the only causal influence of the channel-changing behavior, it is the probable cause we are investigating at the moment.

Descriptive hypothesis is one that postulates particular characteristic of a behavior or provides some specific goal for the observation. In fact, such hypothesis tentatively describes a behavior in terms of the characteristic or the situation in which it occurs. Such hypothesis identifies the various characteristics or attributes of behavior and allows us to predict when it occurs. For example, it the researcher hypothesizes that channel changing during TV viewing occurs more frequently when the person is alone than when he is watching with other. The reality may be that even the number of people present might partially cause channel changing, and the researcher has not stated that. In this way, it can be said that a descriptive hypothesis simply describes the behavior in terms of the various characteristics of the situation and it does not attempt to identify the causes of a behaviour.

Apart from these, the other type of hypothesis that we commonly use in behavioral researches are simple hypothesis, complex hypothesis, research hypothesis, null hypothesis and statistical hypothesis. These may be described as under:

C. Simple hypothesis: Simple hypothesis contains only one or two variables. For example, hypotheses like children from broken homes tend to become delinquent, reward improves learning, aggression is associated with frustration are all examples of simple hypothesis. In all these hypotheses the relationship between only two variables have been postulated. Hence, they are example of simple hypotheses.

D. Complex hypothesis: Complex hypotheses are hypotheses which contain more than two variables and therefore, require complex statistical calculation too. Such hypotheses are called complex because the interrelatedness of more than two variables acting simultaneously is more difficult to assess quantitatively and theoretically.

A hypothesis like children from upper and lower socioeconomic status have larger adult adjustment problems than children from middle socio-economic status is an example of a relatively complex hypotheses.

E. Research hypothesis: A hypothesis derived from the researcher's theory about some aspects of behavior is called research hypothesis or is also known as working as a working hypothesis. The researcher believes that his research hypotheses are true or that they are accurate statements about the conditions of things he is investigating. He also believes that these hypotheses are true to the extent that the theory from which they were derived is adequate. In this perspective, Siegel and Castell (1998) have defined research hypothesis as, "the prediction derived from the theory under test."

F. Null hypothesis: A null hypothesis (H_o) is, in a sense, the reverse of a research hypothesis. It is, in fact, a no-effect or difference hypothesis or negation hypothesis that lends to refuse or deny what is explicitly indicated in a given research hypothesis. Generally, the experimenter or researcher's aim is to refuse this hypothesis on the basis of the obtained results so that its reverse, that is, the research hypothesis can be supported or confirmed.

G. Statistical hypothesis: A statistical hypothesis, also known as alternative hypothesis (H_1), is one that makes numerical expressions of null hypothesis and of research hypotheses. In other words, it is operational statement of the investigator's research hypothesis.

The interrelatedness of research hypothesis, null hypothesis and alternative, or statistical, hypothesis can be explained through an example: Suppose a certain social-psychological theory would lead us to predict that two specified groups of people would differ on the measure of intelligence. This prediction would be our research hypothesis which would state that the two groups differ. Confirmation of this hypothesis would lend support to the theory from which it was derived. To test this research hypothesis, we state it in an operational form as the alternative hypothesis, that is, H_1. One operational way to state this alternative hypothesis would be that mean intelligence scores of these two groups differ or are unequal. The null hypothesis (H_0) would be that the mean intelligence score of the two groups is the same. If the data permits us to reject H_0 then H_1 would be accepted because the data support the research hypothesis and its underlying theory.

In fact the nature of the research hypothesis determines how the alternative hypothesis (H_1) should be stated. If the research hypothesis simply states that two groups will differ with respect to mean then the alternative hypothesis would be simple that mean of the two groups are not equal. But if the research hypothesis predicts *difference with direction*, that is, one specified group will have a larger than the other then the alternative hypothesis may be that the mean of group 1 is greater or less than the mean for group 2.

Thus, we can say that hypothesis is important not just in Social Research but also in every other disciplines. It is often used to limit the scope of research undertaking. A well-chosen hypothesis will increase the chance of success. It is a needed information for the correct application of results found in a research. We can conclude in the word of Kerliner – "There is little doubt that hypothesis are important and indispensable tools of scientific research.

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2. Structural Equation Modelling- A Thorough Insight

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2.1 Introduction:

Structural equation modeling (SEM) has become the most sorted method of data analysis in the modern day social science research. Structural equation modeling is one of the best alternative method in which the researchers are exponentially creating and testing relationship and testing the validity of the most complex and sophisticated models. Through adopting a SEM approach the researchers worldwide are trying to reach the new paradigms of relationship and hypothesis that was new to the world until recent. The SEM is basically a graphical technique in which the user will be developing and redeveloping a series of diagrams to explore the relationship between the variables. This is a most robust technique as this is the technique based on the covariance between the constructs used in the study. In this technique the researcher will be able to test the relationship between more variables at a time. Sometimes the researcher will be able to understand the complex mechanisms such as simple mediation, serial mediation, moderation, mediated –moderation, moderated-mediation and alike through a robust SEM.

This is a graphic based and diagrammatic approach which simplifies the presentation of dynamic interaction between the variables. The viewer or the user can easily verify the diagram for more relevant information. Moreover the result of structural equation modeling throws various kind of information which helps the researcher to verify the statistical validity of the data being used and the results being obtained. In simple words, SEM offers a technique in which the complex interaction between the variables can be simplified and more robust and unexplored relationship between the constructs can be developed. This chapter offers a comprehensive understanding about the various kinds of techniques, methodology used and the prospects of structural equation modeling in the ambits of doing social science research. This chapter further details the various forms of data validity that must be checked and assessed by the researcher before proceeding with structural analysis.

2.2 Benefits of Doing Structural Equation Modeling:

People always prefer diagrammatic representation over theoretical presentation. There is always an extra point of presenting information through diagram than representing it in words. Diagrams always caught the attention of the readers and have great impact in providing meaningful information to the desired stakeholders. The following are the major benefits of doing a structural equation modeling to the researchers.

- This presents the model in a diagrammatic way which simplifies the underlying ideas more effectively.
- This is the most robust mechanism to communicate the conceptual intention of the researcher.
- When the intention of the researcher is to explore the dynamics of interaction between the variables, the SEM is the only rescue as it checks the relationships simultaneously.
- This offers a more simplistic way to conceptualize and operationalizes an idea in the form of diagram.
- Most of the structural equation modeling techniques is covariance based; hence the validity of the obtained result cannot be questioned easily.
- The results of SEM indicate the statistical fitness of the model being developed. This reflects the robustness of the measures being tested and the results being obtained. The SEM provides a series of goodness of fit indices and badness of fit indices that the researcher can interpret to verify the statistical goodness of the obtained results.
- Through testing for SEM it allows the complex model building such as mediation and moderation and assesses the relationship between numerous variables simultaneously. Mediation and moderation is considered to be the most happening interaction between the variables which can be easily included and verified through SEM.
- The SEM canvas offers various drawing tools that can be used to make the obtained results more attractive and comprehensive.
- There are numerous software's that can be used to develop SEM with the help of collected data. Some of the platforms include Amos developed and powered by IBM, Smart PLS, and Lisrel etc.

This chapter is based on the structural equation modeling being undertaken in AMOS which is promoted by the IBM group. AMOS originally stands for analysis of moment structure which analyzes and interprets the critical relationship between the variables. There are many advantages of preferring AMOS over other software's. Amos is software which word basically on the assumptions of covariance between the variables. The covariance act a robust measure that never compromise on the validity of the result obtained. Also, AMOS is much low cost when compared to other platforms and the probabilities of software getting crashed during the model building is comparatively low for this software. There is an added advantage that AMOS supports massive bootstrapping which is seldom provided by the other platforms or has bootstrapping limitations attached with. Also, AMOS offers better path diagram while creating and testing the mediation and moderation between the variables. The authors objectively opines that AMOS is not just a mean software for running SEM but it is the most effective, simple and reliable platform for testing the structural relationship between the variables. This chapter details the various points to be considered and the drawing rules in the AMOS canvas while developing a SEM.

Before proceeding and testing the SEM the researcher must complete confirmatory factor analysis. The various aspects of conducting a confirmatory factor analysis is given below in the next section.

All you need to know about confirmatory factor analysis:

The goodness of the structural model developed by the researcher lies in the confirmatory factor analysis and the various tests of validity being examined by him/her.
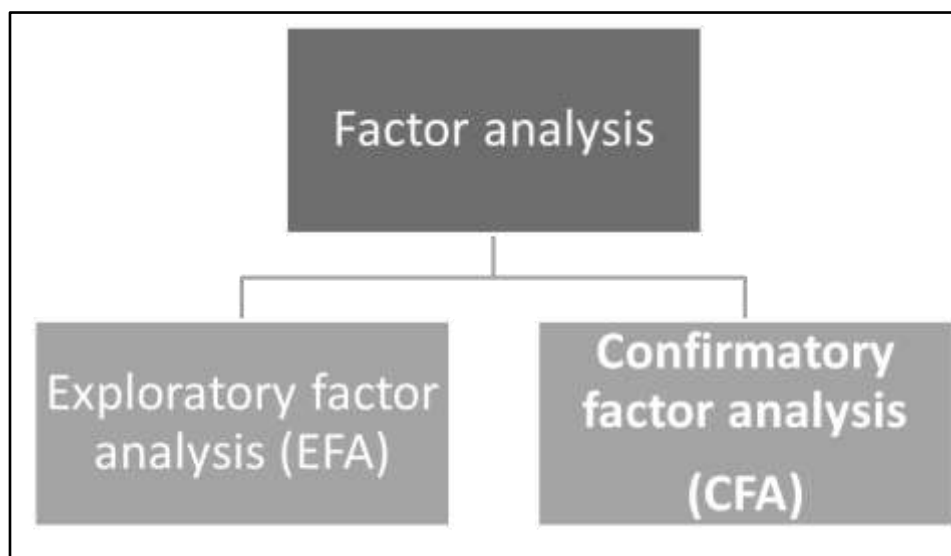
Figure 2.1: Types of Factor Analysis

Factor analysis is a technique that is widely used to explore the underlying factors from a set of observable variables.

It is basically a data reduction technique which is used to extract the hidden factors or unobservable variables from a set of known factors.

There are two types of factor analysis- exploratory factor analysis and confirmatory factor analysis. Exploratory factor analysis or EFA is concerned with exploring and extracting factors from a set of observed items or statements.

It is the first and foremost step in factor analysis. Once the factors are explored and named it is the duty of the researcher to confirm the validity of the factors.

Ensuring the statistical validity of the constructs are necessary step before proceeding with the structural analysis. It is said that ta structural model without a proper measurement model is nothing but a building without a string base which can crumble at any time.

So as a matter of due diligence it is the responsibility of the researcher o confirm the various forms of validity before proceeding with the structural model.
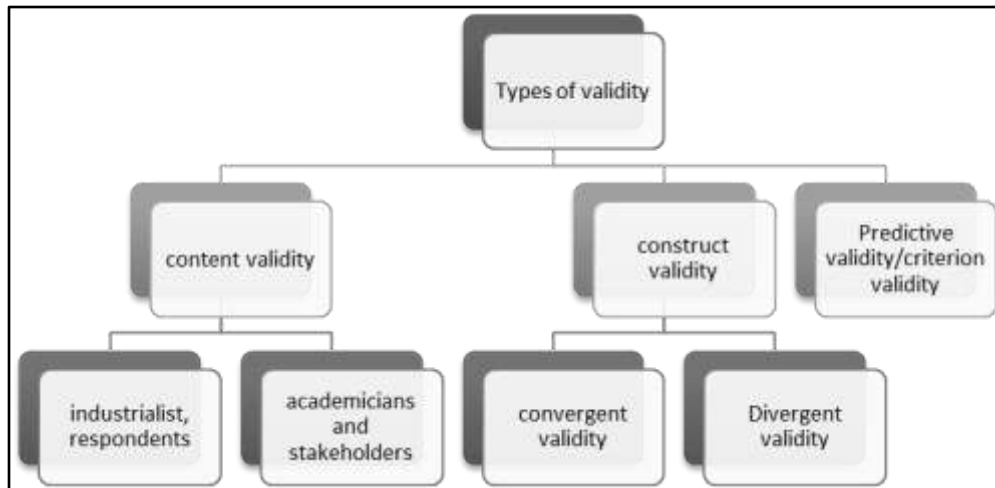
Figure 2.2: Types of Validity Tested in Confirmatory Factor Analysis

The validity of the questionnaire can be measured in multiple ways. Before moving to the different forms of validity it is very essential to understand what validity is. Validity of a research instrument or a construct denotes that the scale measures what it intends to be measured. In other words it measures the items measures the constructs which it is supposedly to measure and it does not measure something else. The different forms of validity are explained below:

A. Content Validity:

This is also known as the face validity of the measures or items being used in the questionnaire. As the name indicate this form of validity measure the facial appearance of a research instrument at a prima facie look. It is generally done by circulating the research instrument among the HR practitioners and academicians for their opinion. On a general basis the researcher supplies the structured questionnaires to a group of academicians in similar specialization and HR managers and industrialist of the study area.

The opinion suggested by them can be incorporated in the research instrument to make it more useful and inclusive. Content validity is a non-statistical measure which is based on the opinion of the stakeholders. It should be duly noted that the opinion of the researcher must be final in designing and redesigning the questionnaire by incorporating the necessary suggestions.

B. Criterion Validity or Predictive Validity:

This predicts the ability of the variable to impact another variable. This shows the predictive capacity of the item being involved in the study. A study with good criterion validity is said to have good predictive capacity. The predictive capacity of the constructs can be measured using the robustness of the r-square value. A study with significant effect size is considered to have good criterion or predictive validity. This shows the extension capacity of the study in the future purposes.

C. Construct Validity:

This is one of the most significant forms of validity. This form of validity test the goodness of each construct entered in the study. This reflects the overall goodness of the construct under the study. Construct validity can be ensured in multiple ways-

- Convergent Validity:

Convergent validity reflects the internal consistency of the item being used in the study. It reflects that all the statement entered in the study reflects and measures the intended construct. For e.g. if job satisfaction is being measured by 8 items and job commitment is being measured by 7 items ensuring convergent validity proves that none of the item measuring job satisfaction should measure job commitment and none of the item measuring job commitment should either measure job satisfaction. This further means that the items should converge together to measure the underlying construct not the other or distinct construct. The convergent validity is ensured through average variance extracted. For a construct to ensure convergent validity the average variance extracted must be greater than 0.5.

- Divergent validity or discriminant validity:

In contrast with the convergent validity this describes the distinctness of each construct entered in the study. While it is said that items should converge, the constructs should diverge from one another. The divergent validity proves that each construct should be separate from one another and should have distinct purpose in the study. The test of divergent or discriminant validity is ensured through the square root of average variance extracted and inter correlation between the variables. It must be noted that the intercorrelation between every variable must be less than the square root of average variance extracted for each factor.

D. Unidimensionality:

This is another measure of validity which measures the unidirectional role of each item towards the measurement model. It delivers the individual role of each item in the measurement model. For an item to be considered unidimensionality the factor loading of the item must be greater than 0.40. Sometimes the unidimensionality of some of the item will be less than 0.40. It is the discretion of the researcher to retain such item in the measurement model. It is always better to delete such an item with lower factor loading, but again the relevance of the item in the measurement model plays a key role i deciding the inclusion or deletion in the measurement model.

The various forms of validity have been illustrated below:

Imagine a researcher intends to measure two constructs namely job satisfaction and job commitment. Job satisfaction is measured by 6 items taken from previous scales, whereas job commitment is measured using 5 statements. Job satisfaction is labeled as JS1, JS2 etc and job commitment is labeled as JC1, JC2 etc.
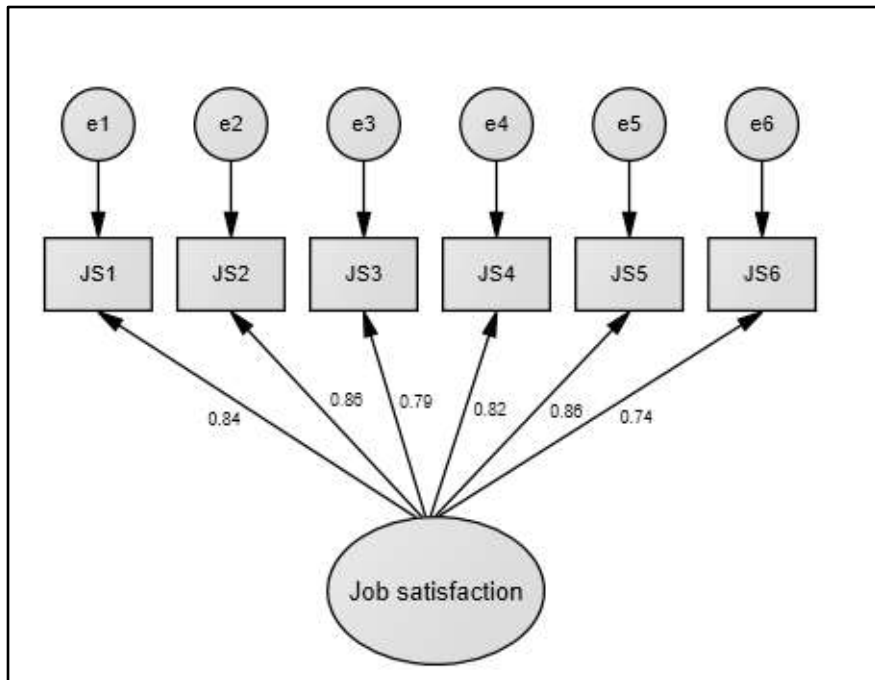
Figure 2.3:
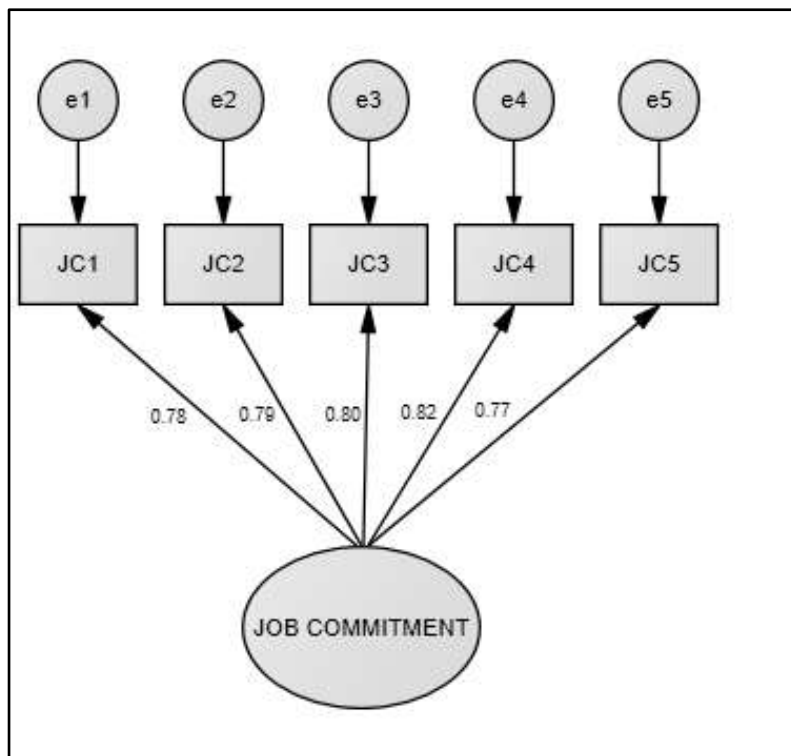
Figure 2.4:

The above figures namely figure 2.3 and figure 2.4 represents the basic measurement model representing job commitment and job satisfaction. The regression coefficients in the pathway show the factor loading of the items.

The factor loading indicates the contribution of each item towards the construct. It can be noted that in the above figures all the factor loadings are above 0.40. Hence it can be concluded that all the items have unidimensionality in measurement.

Next speaking about convergent validity, average variance extracted is the measure that is used to measure the convergent validity. Average variance extracted is the average of the squares of each factor loading of each construct.

Here it can be noted that the AVE value for each of the construct is greater 0.50. Hence there is sufficient convergent validity.

Table 2.1: Showing discriminant validity

Variables	Job Satisfaction	Job Commitment
Job satisfaction	**0.819**	
Job commitment	0.213	**0.741**

The above table shows the measures of discriminant validity. The diagonal values show the square root of average variance extracted. The values down to the diagonal values show the intercorrelation between the variables.

Here it is noted that the inter correlation between the variables are far below the square root of average variance extracted. Hence the constructs are considered to be distinct and hereby the divergent validity is ensured.
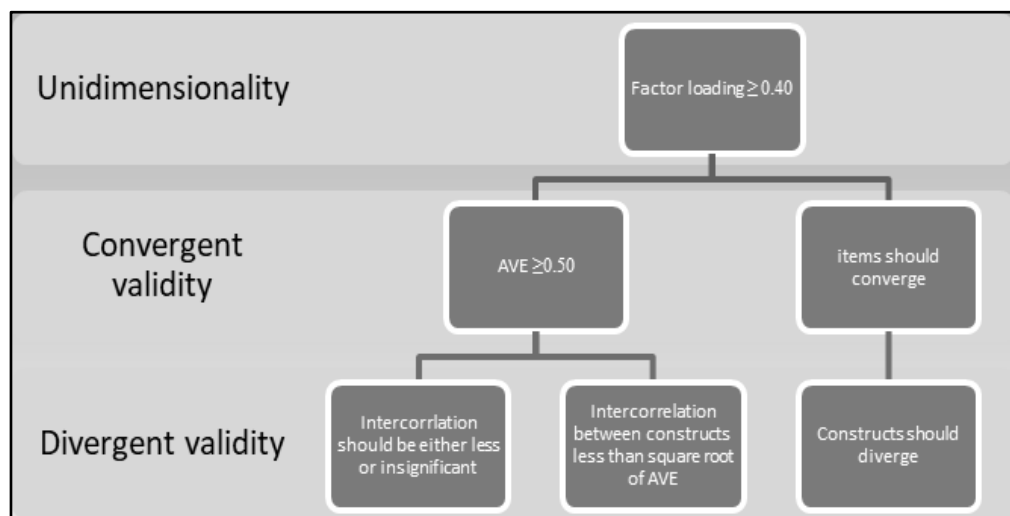
Figure 2.5: Conditions to Satisfy the Test of Validity

The drawing canvas of structural equation modeling- know your tools

Figure 2.6: Representing the Tools of AMOS

The above table shows the basic tools available in the IBM AMOS that will assist the researcher in drawing the structural model. It must be noted that the researcher must be friendly with using the various tools available for drawing.

It must be noted that the tools will be available in a comfortable left hand side whereas the drawing canvas will be available on the right hand side whose size can be adjusted according to the needs.

- The rectangle shows the unobserved variable or the factor
- The ellipse shows the observed variable or the item

- The combination of both ellipse and rectangle shows the entire object. If one clicks on that the measurement model will be on the canvas. With each additional click the new item will be added in the canvas
- The single pointed indicator shows the path
- The double pointed indicator shows the covariance connector
- Then there is the option to add the error term.
- Then there option to select one object at a time, all objects at a time and to deselect all the objects at a time
- The shape of the object can be altered
- The parameters can be moved or can be duplicate
- The eraser help to wipe out the unnecessary objects and mistakes if any in the canvas
- There is option to bring data into the canvas
- The path can be magnified using the telescope available and can be zoomed out
- After drawing the model only the researcher should bring the concerned data into the canvas.
- Remember to save the diagram from time to time
- Always remember not to click on the canvas frequently and multiple times. By clicking on the canvas frequently sometimes the software may get crashed or disrupted.
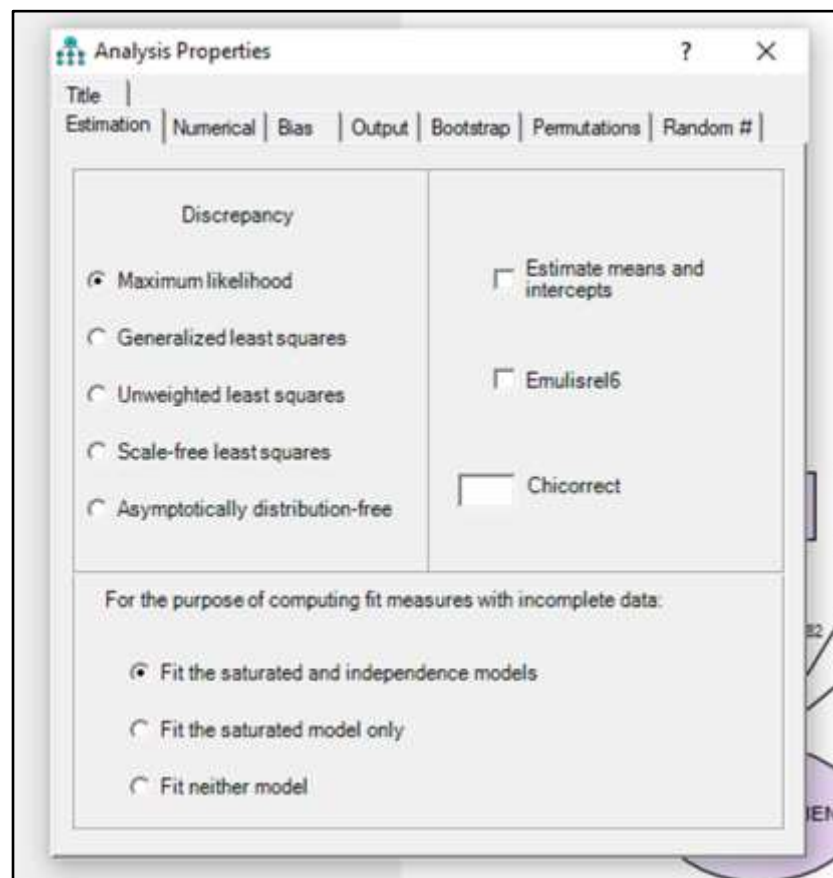
Figure 2.7: A glimpse of the Analysis Properties

All the analysis that you wish to do in AMOS comes under the option analysis properties. In the analysis properties tab there are many options available to choose from. Normally the data work under maximum likelihood option. The researcher has the discretion and should have thorough research methodology to choose from the alternatives. It should be noted that for all these options the shortcut keys are also available. The researcher has to be very much judicial in analyzing the tools, specific methodology, the exact data type of their data, the missing values if any etc for a robust data analysis procedure.
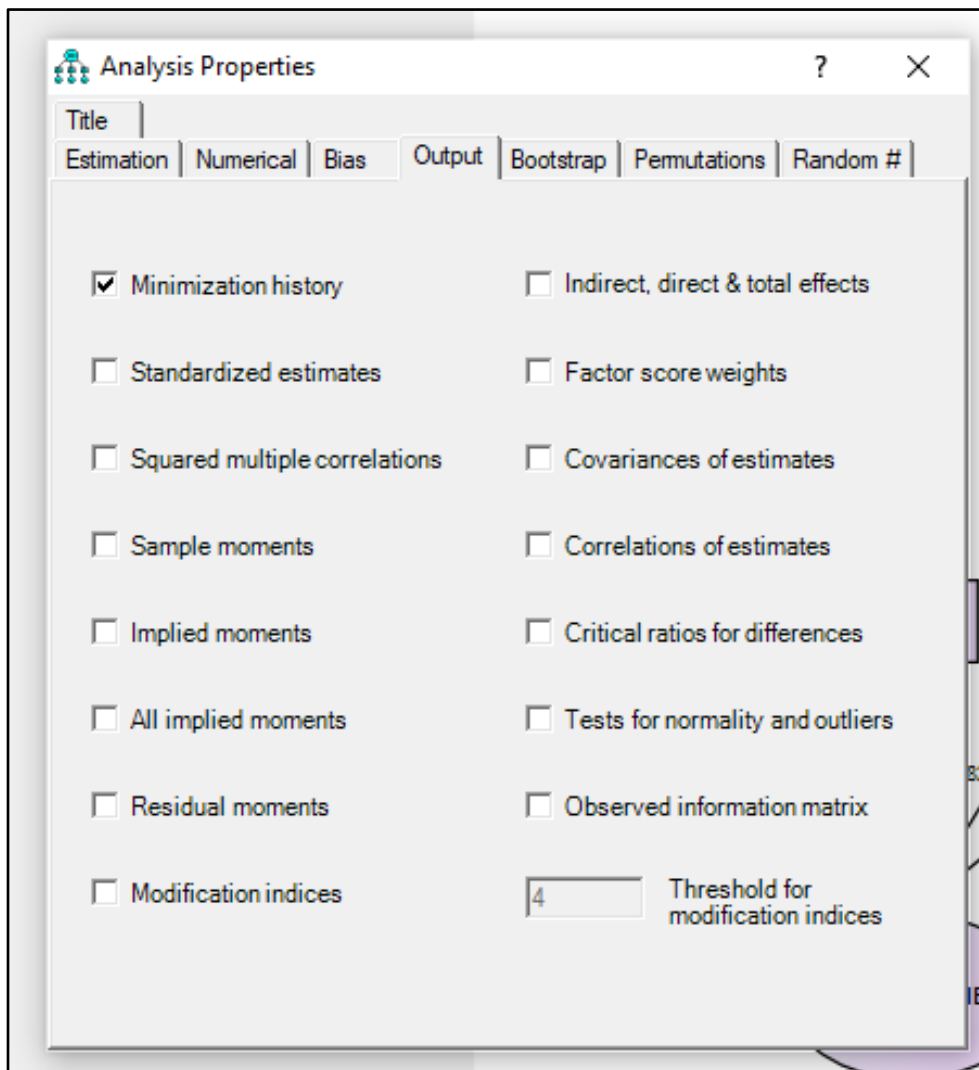
Figure 2.8: A Glimpses of Various Options in the Output Tab

The above screen shows the glimpse of the various outputs available to the researcher to select from. There are no robust rules to select the options. The researcher must be clear about the options he/she wants to get presented in a AMOS output. The researcher must be cautious that whatever output he wants to shows in the work and should not bombard with too much of information.

It must be noted that all the information shown in the thesis must be carefully interpreted otherwise the meaning of the entire model will be altered and the model will turn stale or useless for the stakeholders. It should be noted that there must be thorough justification even for using the modification indices the researcher must go with the proper research methodology in selecting the options for output. Not too much or not too low information should be portrayed by the researcher.
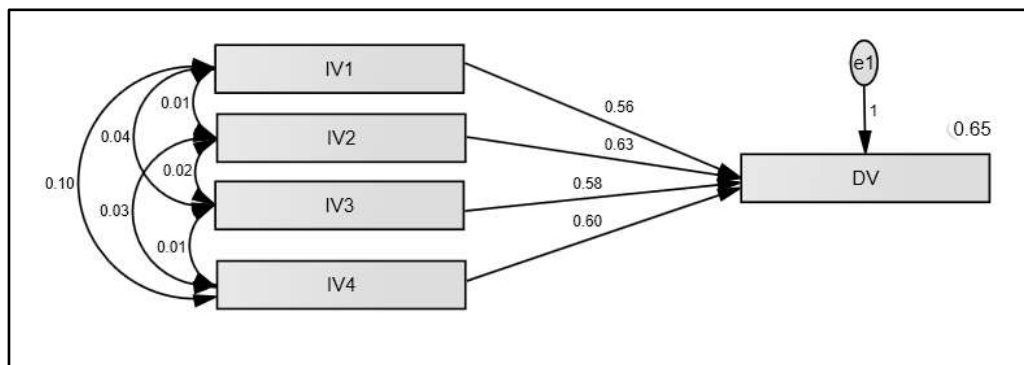
Figure 2.9: Structural Equation Modeling

The above table shows the simple result of a structural equation modeling. The Iv represents the independent variables and the DV represents the dependent variable. The e represents the error term which represents the variation that is not caused by the combined impact of the independent variable. In the above figure 2.9 it may be noted that the independent variable has a error term which explains the possibilities of error variation in the model. It should be noted that always the dependent variable must have an error term without which the entire model won't run in analysis.

The path between the independent and the dependent variable must be connected by a single headed arrow whereas the double headed arrows must be used by the researcher to connect the covariance.

The covariance must be connected for all the independent variables. Error in connecting covariance will have serious impact on the overall model performance. Once the model is drawn and the data has been loaded the researcher should select the options for running the analysis and should select which options to be included in the output generation.

- The output of the structural equation modeling can be interpreted in the following way-
- Any change in IV1 will lead to 56% change in the dependent variable
- Any change in IV2 will lead to 63% change in the dependent variable
- Any change in IV3 will lead to 58% changes in the dependent variable
- Any change in IV4 will lead to 60% changes in the dependent variable
- The R square value shows that 65% of variation in the dependent variable is explained by the change in the independent variable.
- It must be noted that the significance of all the impact and the relationship should be considered while interpreting the results and the diagram.

2.3 Understanding the Fit Indices of Structural Equation Modeling:

The structural equation modeling output throws a series of indices that the researcher must use to interpret the output. There are several indices available which will be used by the researcher to interpret the statistical fitness of the data. The various fit indices available can be termed as badness of fit indices and the goodness of fit indices. The researcher should carefully determine the fit indices to be reported as there are no robust measures to show which the fit indices to be shown are and which are the indices that need not be disclosed.

As a robust measure it must be noted that the goodness of fit indices should be more and more and the badness of fit indices must be very low below the threshold limits. Some of the goodness of fit indices include GFI, AGFI, NFI, TLI, CFI and some of the badness of fit indices includes measures such as RMSEA, RMR, SRMR etc.

The learners must note that there is no agreed consensus on what are the fit indices that have to be disclosed in the structural equation modeling. The researcher should judiciously select the fit indices and their threshold limits as desired by the propounders of structural equation modeling.

2.3.1 Identifying the Moderation and Mediation in a Structural Model:

One of the major purpose for which the researchers use structural equation modeling is its possibilities for testing moderation and mediation through this model. Mediation is known as intervening effect whereas moderation is called as interaction effect. Let us understand first about the test of mediation. A variable is said to be in mediation when the presence of such a variable alters the nature or direction of the preexisting relationship. In other words a variable is said to be mediating, when it affects the course of direct relationship between the independent and dependent variable. Learners should not that there are three types of mediation

A. Full Mediation: When the relationship between the variable have been fully affected or altered by the presence of the third variable it is called as full mediation. For eg; imagine a situation where X and Y are not at all related but the presence of a mediating variable M creates a significant relationship between X and Y. Then the M is considered to be a full mediator. Also the converse can be true. There will be significant relationship between X and Y and the presence of M makes this relationship either insignificant or makes it move in opposite direction. Here also the M is considered to be a significant full mediator. The occurrence of full mediation is a really myth situation in reality.

B. Partial Mediation: This is a more realistic situation in a structural model. In partial mediation the already existing relationship between the variables are getting affected by the presence of the mediator. In other words, when the existing relationship between the variables X and Y is being altered by the presence of mediator M it is considered to be partially mediated. Partial mediation between the variables can again occur in positive and negative manner. When the M increases the relationship between X and Y it is said to be positive partial mediation and if M diminishes the relationship between X and Y it is said to be negative partial mediation.

C. No Mediation: This is the most difficult situation in which the presence of mediation between the variables does not alter the relationship between the variables. The mediation is considered to be absent when the presence of a variable in the model will not touch the existing relationship between the variables. If there is no mediation between the variables, the researcher should make a thorough review of the literature to make sure about the possibility of including or excluding such a variable in the mediation model. The learners should always keep in mind that the presence of mediation should be determined based in the statistical significance of the result and the inclusion of a variable as a mediator or intervening variable should be based on the literature. The researchers should not set any arbitrary variable as a mediator and should run the model. Everything provided in the research should have enough support from the literature. The test of moderation is another important purpose of doing a structural equation modeling. The moderator or a condition is a variable that causes the relationship to happen between the variables. It is a variable or the presence of the conditions which affects the nature of relationship in varied ways. For e.g. Age sometimes act as a moderator in impacting the relationship between the salary and job satisfaction. Here the moderator is not a passer or intervention for the relationship to happen but it acts as a condition for which the relationship can be happen or seize to exist.

Figure 2.10: Theoretical Model for the Test of Mediation
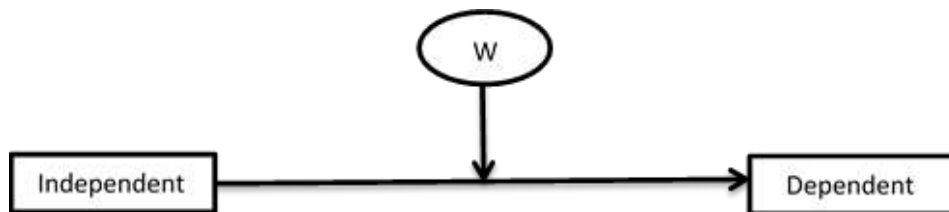
Figure 2.11: Theoretical Model for the Test of Moderation
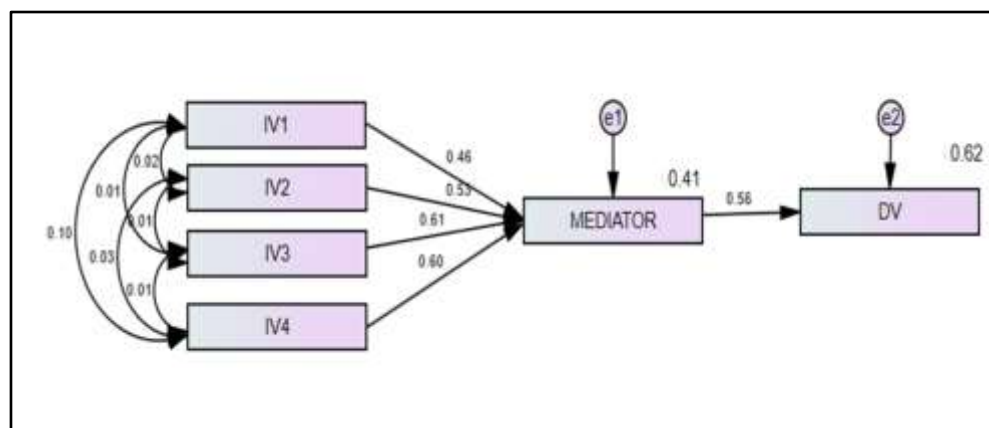
Figure 2.10: Illustrating a Structural Mediation Model

The above figures show the theoretical model difference between the test of mediation and moderation. It can be well noted that mediation act as an intervention and is placed in between the dependent and independent variables. This is the significance of mediation, it act as an intervening variable between the independent and dependent variable. It can be seen from the theoretical model of the moderation that it acts as a condition to carryover the relationship between the variables.

Here there is no intervention happening but a carry forward of the conditional effect between the variables. Both moderation and mediation have significant role in building and testing the relationship between the variables.

2.3.2 Points to Keep in Mind While Working on Structural Equation Modeling:

- There should be proper theoretical support for hypothesizing a structural model
- The mediation and moderation should be supported by proper reviews and justification
- All the variables entering the structural model should be measured on a continuous scale
- The results of confirmatory factor analysis is essential to prove the validity of the results obtained through the structural model
- The structural model should not be considered in the absence of confirmatory factor analysis
- The researcher should make use of all the available tools to make the appearance of the structural model more attractive.
- The researcher can test more complex models involving serial mediation, parallel mediation, conditional indirect effect and conditional interaction effect through the structural equation modeling.
- The possibilities of testing and verifying the unexplored relationship between the variables can be attempted through the structural equation modeling.
- The fit indices should be properly reported along with the necessary threshold limits.
- The researcher must be careful about the various outputs that must be shown in the structural output.
- Every structural relationship included in the model should be based on careful formulation of hypothesis and should ensure sufficient contribution to the literature and practical applications.

2.4 Conclusion:

This chapter had provided thorough insights about the various aspects of structural equation modeling. The researcher had discussed the various aspects of SEM, different types of validity, necessary conditions to satisfy the validity of the data, how to draw a structural diagram in the Amos canvas.

The authors have provided enough information about the various options available in developing and analyzing a SEM diagram. Further the researcher has also detailed the interpretation procedures for a SEM diagram. The knowledge gained through this chapter can be used by the researchers and budding scholars to using SEM as an efficient tool and platform to test complex relationships and sophisticated models.

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3. Data Collection

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3.1 Introduction:

Data are any facts, figures that is useful for analysis and interpretation. For example gender, age, marital status of the respondents in customer satisfaction study. Every research requires data. While conducting statistical investigation, data collection is considered as the first step. The success of statistical investigation depends on the collection, classification, processing, analysis and meaningful interpretation of data.

3.1.1 Need and Importance of Data:

- Provide meaningful information
- Provide a basis for formulation and testing of hypothesis
- Data is required for construction and selection of measurement and scales
- Provide a basis for analysis and interpretation
- The quality of the research findings is depends on the reliability and validity of the collected data
- Data helps to generalizations
- Data helps to theory building
- Data helps to government institutions and companies for policy formulation

3.1.2 Classification of Data:

Data collected by a researcher can be classified as:

A. Primary Data:

Primary data is the data, which are collected for the first time. This data have original character. The researcher collecting primary data for his study. This data meet the specific requirements of the researcher.

B. Secondary Data:

The secondary data are those data, which are already collected by other persons. The data already available can be called as secondary data. It is already collected and presented by someone else for some other purpose.

This data may or may not suitable for the purpose of other research. Secondary data may be internal secondary data or external secondary data

- **Internal Secondary Data:**

It refers to the data that already available within the company or study unit. Here the data can be generated and collected from the activities within a company. For Example sales records, budget records, market research records, job description, bin card etc.

- **External Secondary Data:**

It refers to the data, which is collected from an external institution.it may be private documents or public documents.

For example life history, diaries, letters, government publications, publications by commercial agencies etc. external secondary data may be published or unpublished data.

3.1.3 Selection of Primary and Secondary Data:

The researcher should decide whether primary or secondary data is suitable for his study. The selection process will depends upon the following factors

- Purpose of the study
- Nature of the research problem
- Accessibility of the information
- Availability of the time and cost
- Degree of accuracy and reliability for the study
- Availability of trained investigators
- Convenience of the researcher

Sources of Data:

The source of data always depends on purpose of the research. Generally it can be classified as primary sources and secondary sources.

a. Primary Sources:

These are the original or first time sources from which a researcher directly collects the essential data. For example data is collected to know the awareness of investors regarding investment opportunities

b. Secondary Sources:

These sources contain data, which has already collected or published for another purpose of study.

Apart from this general classification, sources of data can be also classified as:

- Documentary sources
- Library sources and
- Personal sources

3.1.4 Documentary Sources:

A document can provide vast information. This documentary source can be further classified in to individual documents and public documents.

a. Individual Documents:

These are the documents which are recorded and kept by individuals. A person can records his ideas, thoughts and experience in this individual document.

Types of Individual Documents:

- Life history
- Letter
- Diary and
- Memory
- **Life history:** it contains the biological information of individuals. We can collect biographical and social information from life history.
- **Letter:** it provides intimation about the views of individuals to a particular problem. So it provides an idea about the attitude and perception of the individual. The researcher should be careful in selection of appropriate letters.
- **Diary:** it is the most revealing source of personal information. A person can record certain events, feelings and opinions in his diary. So it can be taken as an evidence for the study which is carried out by a researcher
- **Memories:** some people will write their memories regarding with certain events in their life. These documents provide a strong material for social science studies.

b. Public Documents:

Public documents are kept and record by various public institutions. It can be further classified in to published records and unpublished records:

- Published records: it includes various newspapers, magazines, academic journals, historical documents, survey reports and case study reports.

- Unpublished records: these records mainly deal with the matters of public interest. Hence it is not available to the general public in published form. There is an access limitation. For example meeting proceedings of a company.

Merits of Primary Data:

- High degree of accuracy
- High level of control over data
- Suitable for purpose of the study
- It does not require extra filtering
- We are the owner of the information

Demerits of Primary Data:

- Time consuming
- Cost is comparatively high
- In certain studies, it is not possible to collect primary data
- It requires additional investigators, when the study covers a large geographical area

Merits of Secondary Data:

- Ease of access
- It provide an insight to the total situation
- It is helpful for formulation and testing of hypothesis
- Lower cost
- Helps to generate new insights based on already available information
- Suitable if the sample size is too large
- Anyone can collect data

Demerits of Secondary Data:

- It is the already collected information. So it may not be suitable for the study conducted by other researchers
- Less accuracy
- They are not up to date information
- Lack of control over the quality of data
- Not proprietary information

3.1.5 Collection of Primary Data:

Primary data can be collected through different methods. The selection of methods depends on quality of information, coverage of information, time, cost, convenience of the researcher etc.

The following are the important methods of collecting primary data.

- Observation
- Experimentation
- Interview
- Survey
- Simulation
- Projective techniques
- Socio metry
- Focus group
- Content analysis
- Panel method

3.2 Observation:

Observation is an important method of data collection. It can be used in both physical science and social science. There is no verbal communication with the respondents. Here the investigator or researcher observe or notice the things keenly. Observation can be defined as a systematic viewing of a specific phenomenon or condition in its proper setting for the specific purpose of gathering information for a particular study.

3.2.1 Types of Observation:

A. Simple and Systematic Observation: Observation is conducted without a standard procedure is known as simple observation. In systematic observation, observation is conducted based on standard procedures and training is provided for observers.

B. Subjective and Objective Observation: If the researcher observes his own immediate experience it is known as subjective observation or self-observation. When the researcher observe things, which are not related with him, is called objective observation.

C. Casual and Scientific Observation: In casual observation, there is no well preparation. Researcher observes the things by chance. If the observation is conducted based on certain measurement tools it is known as scientific observation.

D. Factual and Inferential Observation: In factual observation, factual information is collected through observation. In inferential observation, observation is conducted for drawing inferences

E. Direct and Indirect Observation: In direct observation, observer is physically present in the observation process. When the observation is conducted by using mechanical devices like cameras or close circuit TV etc., it is known as indirect observation.

F. Participant and Non-Participant Observation: When the observer participated with the actions of the group under observation, it is known as participant observation. The observer penetrates the thoughts of group members and observes their activities, behaviour and emotions. When the observer does not participate the actions of the study group, it is termed as non-participant observation.

G. Controlled and Non-Controlled Observation: In controlled observation, the observation is conducted based on pre-arranged plans. Here the researcher has control over the situation.in non-controlled observation; there is no well-defined plan. The researchers have no control over the situation.

3.3 Experimental Method:

It is the least used method in collecting primary data. In experimental method the group can be classified as experimental group and control group. Experimental group is the group, which is exposed under specific conditions. Control group is the group which is exposed under normal conditions.

3.3.1 Types of Experiment:

A. Laboratory Experiment: In laboratory experiment the researcher tries to measure the cause and effect relationship between the variables. This experiment is conducted in a well settled laboratory. This method is used in both physical science and social science.

B. Field Experiment: This experiment is conducted at the study unit. In other words it is the experiment conducted in a real life situation.

Here the researcher manipulates the independent variable and testing the hypothesis. This method is more useful in social science research.

3.3 Simulation:

Simulation is a modern technique. It is a realistic representation of an imagined situation. Simulation involves construction of various models representing the real situations. This approach is derived from physical science.

Steps in Simulation:

- Identify the situation to be stimulated
- Decided the objectives of simulation
- Develop a mathematical model based on available information
- Collect input data
- Select the type of simulation
- Operate the simulation with the help of various sets of input data

The simulation may be computer simulation, man simulation or man computer simulation.

3.4 Interview:

Interview is the face to face contact between two or more persons. In interview method the data is collected through verbal communication. It is an important tool of collection of data in social science research.

In interview method, there is a face to face communication between interviewer and interviewee. The person who is interviewing is called interviewer and the person who is answered in interview is known as interviewee.

3.4.1 Process of Interview:

- Preparation
- Introduction
- Develop a relationship
- Conduct of interview
- Recording the interview
- Closing the interview

A. Preparation: Preparation is essential for conducting an interview. The interviewer should keep a copy of interview schedule and prepare the list of the name and address of the respondents. He should mentally and physically prepare for the interview.

He should also decide about the way of introduction, the questions to be asked, way of handling the session. If he is not prepared well he is not able to collect necessary information from the respondents.

B. Introduction: Interviewer may be a stranger to the respondents. So he should properly introduce himself. There are no universal norms for introduction.

It depends on the situation of the interview. Interviewer should ensure the cooperation of the respondents through his introduction. The following tips can be used in introduction.

- Greet the respondents with a smile
- Explain the purpose of interview
- Properly address the respondents
- Explain the level of confidentiality of information\
- Explain the use of this study

C. Develop Relationship: Before starting the interview, interviewer develops a good relationship with the respondents. Start the interview with a comfortable topic for both.

D. Conduct the Interview: After ensuring good relationship between interviewer and interviewee, questions are asked to the respondents. If the questions are not understood by the respondents, it should be clearly explained by the interviewer once again.

E. Recording the Interview: Each response should be carefully recorded and reported by the interviewer. These recorded notes can be useful for further reference.

F. Closing the Interview: After the interview, close the interview by the interviewer with a smile to the respondents. If the respondents want to know their whole responses, it should be sending to them also.

3.4.2 Types of Interviews:

A. Personal Interview and Group Interview: Personal interview is conducted with a particular person, and focused on the confidential personal aspects of an individual. It is considered as an effective communication tool. In group interview, investigator interviewing two or more persons simultaneously. Data is collected from a number of respondents with a common interest.

B. Formal Interview and Informal Interview: Formal interviews are conducted in formal structure. Here the interviewer collecting information from the respondents with the help of a set of pre-determined questions.

In informal interview the interviewer has freedom to make alternations in the prepared questions. Interviewer can ask questions accidentally.

C. Focused Interview: In this interviewer give focus attention on a particular life event or experience of the respondent. Usually unstructured questions are asked in focused interview

D. Diagnostic Interview: Diagnostic interview is carried out among patients. In this, investigator tries to understand the reasons of the problem. For example a doctor diagnose the disease of a patient.

E. Treatment Interview: The objective of this interview is spread awareness. For example treatment interview conducted with patients to increase their awareness on causes of their disease and scope of further treatment.

F. Telephone Interview: If the investigator used telephone for conducting personal interview, it is termed as telephone interview. The respondent is connected through telephone and researcher gather information through telephone.

G. In-depth Interview: It is mainly used in motivational research. Here the interviewer collects information regarding the underlying motives and desire of the respondents. In depth knowledge about the situation or event can be acquired through in-depth interview.

3.5 Delphi Method:

Delphi technique is used when expert solution or answers is needed. It is a group process involving a group of experts. The facilitator selects a group of experts. Then discussion is going on with these experts on a topic of interest. They provide their view points and solution to the problem.

3.6 Panel Method:

In this method data is collected from the same sample respondents by using a mail or personal interview method. This method is widely used in consumer behaviour and advertisement effectiveness studies.

3.7 Survey Method:

Survey is a descriptive research method. Survey can be conducted for collecting responses from the sample respondents. Data can be collected through using a questionnaire or schedule. This method requires expertise, careful planning, and accuracy in interpretation of the results

3.7.1 Characteristics of Survey Method:

- It is considered as a field study
- This method can cover huge population
- This method can cover wide geographical area
- This method is applicable for intensive studies
- It is useful for describing a phenomenon and analyse the cause and effect relationship

3.7.2 Types of surveys:

The surveys can be broadly classified in to cross sectional survey and longitudinal survey

A. Cross Sectional Survey: This survey is used to collect data from the sample respondents at a single point of time. For example survey conducted to know employee job satisfaction during the year 2020. Here we can collect the data, conduct analysis and find out the results at a single point of time.

B. Longitudinal Survey: In longitudinal survey, researcher collects data from the respondents over a period of time. For example surveys conducted to know the effectiveness of advertisement before and after an advertisement campaign is conducted.

Methods of Survey:

Survey methods can be classified as census survey method and sample survey method.

Census Survey Method:

In census survey, the researcher collects data from all units of the population. Census method helps to increase accuracy of collected data. This method requires more time, cost and resources.in certain cases it is not possible to collect data from the entire units of the population. So sample survey method can be used in that situation.

Merits of Census Survey Method:

- More accurate survey method, because this method covers each and every units of the population
- More reliable method
- Collected data can be used for various surveys and depth analysis
- Errors can be easily detected

Demerits of Census Survey Method:

- It requires more time and money
- It requires large number of trained enumerators
- It is not possible to conduct a census survey, if there is an infinite population

Sample Survey Method:

In sample survey method, the researcher selected a smaller representation of the population, known as sample. The entire study is conducted based on sample respondents. The process of selecting samples from the population is known as sampling. Various sampling technics are available for selecting samples from the population.

Merits of Sample Survey Method:

- Very useful to collect primary data regarding personal information, attitudes and behaviour of the respondents
- It helps to make generalizations based on samples
- This method is comparatively less time consuming and less expensive process than census survey method

Demerits of Sample Survey Method:

- The success of this method depends on cooperation of the respondents
- There is limit in collection of information from sample respondents
- It is not suitable for historical studies
- There is a chance for sampling errors
- There is problem of reliability and validity

3.8 Projective Techniques:

This method encourages the respondents to reveal their unconscious feelings, attitude and emotions. In marketing research it is used to access the unconscious mind of the customers. In this various tests can be used to project the personality traits of the respondents.

Projective techniques are widely used in psychology to study the psychological and unconscious behaviour of people. The following are important projective techniques.

A. Word Association Test: In this test, researcher says a list of words and the participant is to respond with the first word that comes to their mind. This test is used to identify the words which have high association. Usually 50 to 100 words are distributed to respondents.

B. Sentence Completion Test: In is the extension of word association test. In this researchers distributed a list of incomplete sentences and ask respondents to complete them. The researchers can analysing the feelings of the respondents through observing the way they complete the sentence.

C. Story Completion Test: In this test researcher distributed stories to the respondents instead of sentence. Then the respondents are asked to complete the story.

D. Verbal Projection Test: In verbal projection test, respondents are asked to explain about the situation or comment on what other people do. Researcher observes the explanation and find out the motives and behavioural patterns of the respondents.

E. Cartoon Projection Test: In this test researcher shows various characters in a situation or event and ask respondents to describe what the characters are doing and explain about the situation in cartoon.

F. Pictorial Techniques: Many pictorial techniques are also used under projective techniques such as thematic appreciation test, Rorschach in blot test, holtzman inkblot test, rosensweig test etc.

3.9 Sociometry:

Sociometry is the technique which is used to measuring the degree of relatedness among the peoples in society. Sociometry is the best technique for reducing conflict and improves communication in a group. This method is developed by Jacob Levi Moreno in 1934. Sociometry is a powerful technique for improving the interrelationship between the members in group.

Objectives of Sociometry:

- To explore social choice patterns of people
- To reduce the conflicts in a group
- To facilitate constructive changes in individuals
- To defines the roles and responsibilities of members in a group
- To improve the interpersonal relationship between people
- To increase group cohesiveness

3.10 Focus Group:

It is a technique in which a skilled expert or facilitator leads a small group of participants in an unstructured discussion about a specific topic. The moderator is the leader of focus group discussions.

Uses of focus group discussion:

- To assist for the preparation of questionnaire
- To assess the needs of people
- To identify the factors while people making decisions
- To test existing policies and procedures
- To recruit new employees in an organization
- To evaluate the effectiveness of a marketing program

Steps in focus group discussion:

- Determine purpose of the focus group
- Selection of the participants
- Intimation to participants
- Providing fee and refreshment
- Selection of facilitator
- Formulation of protocol for the session
- Proper recording of discussion
- Conduct discussion and follow up

3.11 Content Analysis:

Under content analysis, the most important contents of any documentary materials such as books, magazines, articles are analysed. In content analysis the researcher categorize the entire data. This technique is most popular in social studies.

Steps in content analysis:

a. To identify the universe of content that is analysed under the study
b. To find out the specific characteristics to be measured under content analysis and then the universe should be divided on the basis of these characteristics.
c. Categories it on the basis of objectives of the research
d. Quantify this data in a suitable form, for example ranking method.

Tools for collecting primary data:

Various tools are used for collecting primary data from the respondents. Among these tools the widely used tools are questionnaire and schedule. Both these tools are adopted by private individuals, research scholars and various organizations for collecting primary data from their respondents. The key difference between questionnaire and schedule is that, questionnaire is filled by the respondents and schedule is filled by the enumerator.

A. Questionnaire:

A questionnaire is filled by respondents and it consists of a number of questions printed in a definite order on a proper form. The success of questionnaire is depends on the reliability and validity of the collected information.

- **Types of Questionnaire:**

a. Structured and Unstructured Questionnaire: Structured questionnaire is definite and concrete in nature. In the questions are presented in a structured format. Same set of standardized questions are distributed to all respondents.in unstructured questionnaire, questions are not arranged in a well manner and some of the questions are partially incomplete.

b. Fact and Opinion Questionnaire: In fact questionnaire is designed to collect factual information from the respondents.in opinion questionnaire respondent's opinion, perception or attitude regarding a particular phenomenon is collected.

c. Open form and Closed form Questionnaire: In open form questionnaire, the respondents can freely record their Reponses.

There are no restrictions regarding responses. In closed form questionnaire, short responses from respondents are collected. Most of the questions are dichotomous questions.

Guidelines for the preparation of questionnaire:

While preparing questionnaire, researcher should consider some points. The points are listed below.

- Use the language that is comfortable to the respondent
- Avoid lengthy questions
- Avoid questions having double meaning
- Forecast the frame of responses from the respondents
- Protect ego of the respondents
- Decide whether direct or indirect questions are more needed
- Decide whether general or specific questions are more needed
- Avoid biased questions
- Avoid misleading questions
- Ensure questions should be limited to single idea or concept at a time

Merits of Questionnaire:

- Economical
- Uniformity
- Free from bias
- Convenient tool
- Reliable tool

Demerits of Questionnaire:

- Limited use
- Lower response rate
- Misinterpretation of data

B. Schedule:

A schedule is a set of questions which are asked and filled by the enumerator through face to face interaction with respondents. The schedule may contains both direct and indirect questions

Steps in schedule preparation process:

- The problem of the study should be divided in to various portions. Researcher must understand the problem clearly before division
- These portions or aspects of the problem are further subdivided in to various components
- The next step is preparation of questions related with the study
- All the questions are well ordered and properly arranged in schedule

Merits of Schedule:

- Most suitable tool, when the respondents are illiterate
- Suitable tool when there is a small non-response rate
- The collected data through using schedule is more reliable

Demerits of Schedule:

- Costly tool
- In certain situations more enumerators are needed to collect data
- The success of this tool depends on efficiency of enumerators

4. Analytical Study of Legal Research

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4.1 Abstract:

The word 'research' is derived from the word 'recerch', which is French. It means that, 're' indicate the 'again' and 'search means to test or examine. In other word, research means to search for new facts or modify the old or existing facts. While doing research in any area, it requires the careful and systematic study along with, the critical inquires, diligent investigation to discover something. The 'legal research' means the organized investigation of problems or situation and concerned with laws thereof. The term 'law' is wider in nature and it includes the various Acts, Rules, Regulations, Codes, and Constitution etc. The legal research take into account the social and behavioral phenomena and try to discover new legal facts as well as makes the verification of previous one, to give suitable solution to the legal problems. The legal research work has played and playing very crucial role in the development of human being and society. Law being an instrument of social change, whenever, legal research take place, it found something new, which is beneficial for the society, resulting smooth working in the society by governing the human behavior. For that, researcher should always be inspired for the research work and capable of doing all the required hard work, analysis of research topic by following the ethical standard in his research work. He should not get involved in any kind of plagiarized act and due acknowledgement must be given for the references or use of other material, if any. And also, he should not make violation of copyright. The legal research should follow every steps of research, with scientific attitude or mind, high degree of imagination to understand the intangible aspect of society, patience and perseverance, clarity in thinking. Apart from these, the researcher should have the thorough knowledge of subjects, various techniques and choose the most suitable technique, curiosity in research topic with unbiased attitude. After all, we should not forget that, in the research work, it is expected to produce original outcome.

Keywords: Research, Legal Research, Ethics, Research Problem, Hypothesis, Research Design, Type of Legal Research, Data Collection and Analysis.

4.2 Analytical Study of Legal Research:

4.2.1 Introduction:

The word 'research' is derived from the word 'recerch', which is French[1]. It means that, 're' indicate the 'again' and 'search means to test or examine. In other word, research means to search for new facts or modify the old or existing facts[2].

While doing research in any area, it requires the careful and systematic study along with, the critical inquires, diligent investigation to discover something. The term 'research' is defined by the Encyclopedia Britannica, as a "Research is an act of searching into a matter closely and carefully, inquiry directly to the discovery of truth and in particular the trained scientific investigation of the principles and facts of any subject based on original and first hand study of authorities or experiment.

There is another simple definition given by the Redman and Mary[3]. They have defined the term 'research' means systematized efforts to gain knowledge.

4.2.2 Meaning of Legal Research:

The 'legal research' means the organized investigation of problems or situation, concerned with laws. The term 'law' is wider in nature and it includes the various Acts, Rules, Regulations, Codes, and Constitution etc.[4] The legal research take into account the social and behavioral phenomena and try to discover new legal facts as well as makes the verification of previous one, to give suitable solution to the legal problems. There are numbers of appealing factors behind the legal research such as, interest about the unknown, craving to understand the cause and effect of legal problems, due to arrival of unusual and unanticipated situations, sometimes the researcher might be the desire, to verify the old laws or to discover the new procedure suitable to govern the behaviors in the civilized society.

4.3 Objectives:

The legal research can be done with object, to get acquainted with the knowledge of human society and how it give rise to the legal matter or issue. And to know the operation of law in such society. Because, we must understand that, the law is an instrument of any kind of social change. It is closely connected with the society. And increasing evils in the society such as rape, murder, suicide etc. forces to have through study of human organization of society and its actual working. This scenario encourages to do the legal research. Apart from these, the other reasons behind the legal research can be, to discover something novel facts, to acquaint with new legal situation, to develop the new legal concepts, to study any law with critical view, to get the knowledge of consequences of any new law, affecting largely to masses. In other word the legal research can be done with an objective of evaluative, explicative, impact analysis, predictive, interactive, interpretative, collective etc.[5] The primary purpose of any kind of research is to search for the truth[6]. And other purposes are, to discover or interpret and thereby develop the human knowledge for the betterment of society.

4.4 Importance of Legal Research:

The law, being a tool, regulate the human behavior in the society by setting certain norms. And if required, the law mold the social attitudes and people's behaviors in order to get the expected atmosphere in the society. Whereas, the society get changed with the passage of time, the law also required to be changed suitably. It means that, law should be dynamic as per the required society. Because, many times, the existing legislations get failed to handle the social evils or problems in better manner.

Therefore, such situation forces them, to have legal research upon it to ascertain the current laws, to focus on the ambiguity, to critically examine the present laws and to make suggestions for the creating better situation by developing the law. The legal research deals with questions of law or facts in relation to problems of society or human behaviors[7]. The research plays two noticeable roles like contributing to insight of knowledge and to resolve the issues or problems of society[8]. It is the intellectual activities and it became the integral part of academic activities and also currently connected with sociology, economics and political sciences, management etc.

Ethics: It is rightly said that, every action or activity should done by following the ethical norms of it, so that, the public would benefit from it, truly. Likewise, in legal research and other research too, the ethics is an important part. There are several benefits, if the researcher follows the ethics, while doing research. The ethics, promotes the truthful knowledge and avoid the error. Moreover, it encourage, the trustworthiness and accountability as well as fairness and ensure that, the researcher can be held accountable for his work to the public at large. In addition to this, the ethical standard in legal research help to produce the quality research, which resulted in public support by way of fund for research project[9].

The researcher should not involve in plagiarism and copyright violation. When researcher, plagiarize it means he cheat for himself, by showing intellectual dishonesty and intellectual immoral[10].

There are some general ethical principles, which should be present for any kind of research activities including in legal research. First and foremost, the honesty should be in the data, result, research methods etc. And it should not be the fabricated or misrepresented research work. The bias should be avoided and the researcher should act sincerely and carefully to avoid the careless mistakes and negligence. The research should be open to criticism and not to use the unpublished data. If any data or information is get used, then it's should be acknowledge properly. Researcher should maintain the confidentiality about the communications, personal records, military secrets etc. and should respect the human privacy and autonomy if needed. He should help, to educate and advise the students as and when required. Moreover, while doing research the researchers should keep in mind the social responsibility i.e. his research work should contribute for the social good and mitigate or prevent the social evils or harms through research. He should be aware about all the prevalent laws, governmental policies etc. while doing research[11].

4.5 Identification and Formulation of Research Problems:

As the research activity involves the many steps, the identification and formulation of research problem is one of the steps therein along with the formulation of hypothesis, collection of data, and analyzing the data collected etc. It is the topics that the researcher is interested to make through study thereof to find the answer to the problem[12].

Therefore, the legal research problem, must be valuable for study with social and legal relevance, and also it should provide the practical solution to that problem or issue. Moreover, the legal research problem must be verifiable and testable having originality and clarity in scope with availability of required data needed for the research[13].

While formulating the general topic into the specific research problem, the researcher should, after reading of required literature should note down the questions that comes in his mind and thereafter, review those questions and think over it, whether it is useful or not, the scope of it, the availability of time and funds. And in the end, the important questions should segregated from the other subsidiary questions, which would be the research problem for research[14].

A. Hypothesis: When the researcher choose the problem in legal research, the next step is to formulate the hypothesis on the basis of material studied. It is a one kind of suggestion of tentative solution to problems in the form of preposition, which can be testified, is called the hypothesis. The term 'hypothesis' is the combination of two words 'hypo' and 'thesis'. The 'hypo' means under or tentative and the word 'thesis' means general statement or opinion about the solution of problem[15]. As per the Webster, it is the guesses made by the researcher, which either solve the problem or guide him in further investigation[16]. The process of formulating the 'hypothesis begin with the observation and thereafter it reflect in statement or preposition by following either deductive thinking or inductive thinking.

In the end the researcher get verification of it, by actually testing to solve the problem. Therefore, the hypothesis has wider importance in legal research, without it, the research can be unfocused and less useful. It provide the basis for the research methodology and make the result of legal research more accurate and explicit in nature[17].

B. Research Design: After formulation of hypothesis, the research design is used to make proper planning, while doing research work. Due to such logical and systematic plan, the researcher get the clear-cut idea about the specific objectives, methodology to be adopted, and the outlines for collection of data along with the depth analysis of collected data. Due to such research design, the research operation goes smoothly and provide the maximum information in economic manner in less time with less energy. It helps, to understand the availability of resources and time as per the objective of research.

The research design helps to produce maximum inaccuracy in research by adopting particular required methodology resulting to decide suitable method. It makes the efficient research. It is the firm foundation for the entire edifice of the research work[18]. It seems that, the research design has very much importance in the research work and it is used just like master plan for the research activity. However, sometimes due to under estimation of research design value, the researcher gives the misleading conclusions, which get resulted in failure of a related research. Hence, utmost care should be taken by the researcher, to form efficient and correct design so that, research work does not becomes useless.

4.5.1 Types of Legal Research:

To perform the research operations, researcher has to use certain techniques or methods while conducting the research. It requires, to follow the research methodology, which is the way to solve the problem of research[19]. There are different methods to do the legal research and the most common types of methods used in legal research are doctrinal or non-empirical and non-doctrinal or empirical methods. In case of doctrinal legal research, the work start by taking one or more legal statement or preposition, for the focus of study.

In such type of research it mainly focuses upon the library, to get the material which generally known as the secondary data such as statutes, judgment, journals, case laws, magazines, books. Apart from this the researcher also get reference of committee reports, legal history etc. which are conventional sources. After collection the required material the researcher start to analyze it, to formulate the conclusion of his research topic.

On the other hand, in case of non-doctrinal or empirical research, involves the field work or in other word first hand study by the researcher, because its majority of data can be college by studying primary data, which is not available mostly, in the traditional legal sources. Its primary focus is upon, to assess the impact of non-legal event on legal principles/doctrines or vice-versa[20]. Such type of research, emphasis upon the consequences of law on the society or sometime for the passing of any law. To ascertain the impact of law, there is need to have the primary data to have first-hand study, which can be collected by way of, case law method, questionnaire, interview, schedule etc. Although, these two types of methodology get used in legal research, the difference between them, is almost invisible. Because, in most of the times, somewhere the doctrinal and non-doctrinal methods takes place while doing legal research[21].

4.5.2 Data Collection and Analysis:

This is the important steps of any kind of research work. Without collection and analysis of it, the research work can't get completed. There are two important sources of data, primary data, which can be collected by way of interview, survey, questionnaire etc. and secondary data from books, committee reports, case laws, statute etc. The secondary data could be used in majority of time in doctrinal legal research and first hand or primary data is useful in case of non-doctrinal legal research.

Hence, researcher should choose, proper data collection tools, which should be objective and precise in nature. Data can be in the form of facts, figures or in any other form, which became the basis of research study and useful for the analysis. By analyzing, such raw data the appropriate inference can laid down in the research. The researcher uses the collected data for the testifying the hypothesis formulated at the beginning of research. The maximum availability relevant data produces the maximum accuracy in research work[22].

4.6 Conclusion:

The legal research work has played and playing very crucial role in the development of human being and society. Law being an instrument of social change, whenever, legal research take place, it found something new, which is beneficial for the society, resulting smooth working in the society by governing the human behavior. For that, researcher should always be inspired for the research work and capable of doing all the required hard work, analysis of research topic by following the ethical standard in his research work. He should not get involved in any kind of plagiarized act and due acknowledgement must be given for the references or use of other material, if any and also he should not make violation of copyright. The research should follow every steps of legal research, with scientific attitude or mind, high degree of imagination to understand the intangible aspect of society, patience and perseverance, clarity in thinking.

Apart from these, the researcher should have the thorough knowledge of subjects, various techniques and choose the most suitable technique, person interest or curiosity in research topic with unbiased attitude. After all, we should not forget that, in the research work, it is expected to produce original outcome.

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2. Ibid. See also The P.V. Young defines, 'Social research' as the systematic method of discovering new facts or verifying old facts, their sequence, inter-relationship, casual explanations and the natural law, which govern them."
3. Dr. S. R. Myneni, "Legal Research Methodology" Allahabad Law Agency, Faridabad, 3rd Edition 2009 at P 13
4. Ibid
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6. See Supra
7. Monoj Kumar Sinha (Ed), "Legal Research Methodology", LexisNexis, Haryana 2017 at P 6 CF S.K. Verma, Doctrinal Legal Research: Methods and Methodology", Chapter I at PP 3-6
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11. Ibid at PP 43 to 44
12. The term 'problem' is derived from the Greek word 'Proballein', which means, 'a question proposed for answer' CF See Infra
13. Dr. Anshu Jain, "Identification and Formulation of a Research Problem" Chapter 6 at PP 65-67 CF See Supra
14. Ibid
15. Dr. Mona Purohit, "Legal Education and Research Methodology", Central Law Publications, Allahabad 1st Edition 2010 at P 120
16. Ibid. According to M.C. Guigan, "Hypothesis is a testable statement of a potential relationship between two or more variables that is advanced as potential solution to the problem".
17. S. R. Myneni, has mentioned that, "In the absence of hypothesis the researcher is like a sailor on the wide sea, without compass or rudder"
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19. See Supra at foot note 7 p- 9
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5. Measurement in Social Sciences

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5.1 Introduction:

In conclusion, whereas reliability is necessary in research, reliability alone is not sufficient. If data is valid, it must be reliable. When a research produces very different scores on a test whenever it is conducted, the test is not likely to predict anything. On the other hand, if a test is reliable, that does not mean that it is valid. For a test to be reliable, it must also be valid. Reliability and validity are conceptualized as trustworthiness, rigor and quality in a qualitative paradigm. It is also through this association that the processes to achieve validity and reliability in research get affected from the qualitative Social Science research studies society in various frames hence it cannot be accurately measured in objective terms therefore it adopts various methods which can be applied for gathering and analysing data. Measurement is important in research. Measurement is important because it gives us a picture of what is going on. Measurement aims to assist researchers in testing the questions which are in their mind regarding behavior of people. For checking significance or insignificance of social science researches it is essential to apply quantitative and qualitative methods. Statistical tools make it possible to accept or reject the hypothesis.

Without this replication of statistically significant results, the experiment and research have not fulfilled all of the requirements of testability. This prerequisite is essential to a hypothesis for establishing itself as an accepted scientific truth. Through rational observation the researchers may be able to study the variables, their quantity or sample size for predicting about population, and also reveal about the degree to which behavior may be ascertained in all these steps what is significant is the use of various aspects of measurement like accuracy, validity, replicability and reliability. In research methodology Measurement may be defined as the research process of observing and recording the observations that are collected from social environment (Trochim: 2020). He has explained the four levels of measurement, that is nominal, ordinal, interval and ratio. Next he has also explained the different approaches to measurement in social researches, of which the prominent approaches include:

Survey method for designing questionnaire to be used while interviewing subjects for data collection. Scaling which involves assessing subjects' views about various social issues through rating method. First developing the tool and then using it for questioning the people, accumulating their views and then analysing them. Qualitative research which tries to assess non-numerical aspects of the population to be studied and then make categories to study them rationally. Observation from outside or Unobtrusive measurement which includes checking reactions or behaviors of people from distance so that they are not conscious that they are being watched, hence they perform naturally.

Measurement usually starts with observation which has been the main instrument in the hands of social scientists to predict future aspects of various phenomena studied and then using various quantitative or qualitative measures to prove what they have assumed. According to Maxim (1999), measurement implies empirical study of phenomena to be studied using numerical range for giving interpretations which are more accurate and may be quoted in numerical terms. Without measurement, researchers can't interpret the data accurately and systematically.

Thus, measurement is a way to explain your study to others in a very clear terms, making it explainable. Next, we can make a comparison of various variables using measures. For example we can compare two groups; such as conducting a study to see if urban men are better at solving Mathematics than rural men. It could also be a comparison of changes over time between varied occurrences. Measurement is often employed in quantitative research more than qualitative research. Quantitative measurement enables researchers to make accurate judgement regarding features, characteristics and giving comparative view about matter to be studied.

For example if height of different persons in a family varies than research using past records of family may help in genetically proving why this has occurred. Past records of many generations of that family may help in analysing why the heights are varying.

If nature of persons of the same family may be studied than difference in nature may be attributed to heredity and environmental factors. This has only surfaced through researches going on since past. Measurement is the means to assess the various aspects of social systems studied but it is not itself a system, it is a means for comparison and analysis for comparing various segments of the system. Measurement in research can be categorized into four different levels: nominal, ordinal, interval, and ratio measurements. According to McClendon (2004), Nominal measurement is a process of assigning numbers to number of cases which are to be considered for any purpose. It is used for counting purpose only hence is the lowest form of measurement. In essence percentages are used in this level of measurement, for e.g. percentage of UP students vs. percentage of Maharashtra student vs. Punjab students in a class. Next level of measurement is ordinal measurement, in this systematic placement of population in terms of rank or position is applied. Adi Bhat ( ) has defined Ordinal measurement as "the second level of measurement that reports the ranking and ordering of the data without actually establishing the degree of variation between them." Ordinal level of measurement is the second of the four measurement scales. "Ordinal" indicates "order". Ordinal data is quantitative data which have naturally occurring orders and the difference between is unknown. It can be placed in order like 1st, 2nd, 3rd etc till the whole population is provided rank. This positioning is used in ranking engineering aspirants from first to the last to decide cutoffs for IIT, NITs, etc. The ranks are given but the difference between ranks cannot be clarified by ordinal measurement. Next is interval measurement. The Encyclopedia of Social Research Methods (2004) published by Sage defines Interval Measurement as one where the distance between the attributes, or response options, has an actual meaning and is of equal interval. Differences in the values represent differences in the attribute. Interval measures have fixed measurement units, but they do not have a fixed, or absolute, zero point. For instance when rating students to assign grades the scores of all students are put from top to bottom in interval scales, which may be of an interval of 5, 6 or whatever has been decided by the grading committee.

If a student gets a score of 53 he is placed in the interval which includes that number in its interval, e.g.in the range of 5 scores in one interval from 40 till 100 the score of 53 will fall in interval including scores from 50-55. This is the method of applying interval. Interval measures are now common in social research because the attributes that are measured are usually converted into interval scales as given by Likert () for explaining the degree to which the attribute is present in persons.

Ratio scale is the fourth level of measurement and possesses a zero point or character of origin. Bhatt has defined Ratio scale as a type of variable measurement scale which is quantitative in nature. Ratio scale allows any researcher to compare the intervals or differences in absolute terms magnifying differences to the most molecular levels. Bhat explains that a ratio scale is the most informative scale as it tends to elaborate about the order and number of the objects between the values of the scale. The most common examples of ratio scale are height, money, age, weight, etc. Cutoff is usually decided on ratio basis to determine pass or fail, distinction or not, etc.

An important part of social science research is the conversion of human behavior study in quantitative terms. Descriptive views are transformed into numbers through categorization as specified by Likert. This view has also been highlighted by Drost () Who states that observed behavior are quantified using measurement instrument. The measurement of human behaviour using statistical methods has made it a widely applied empirical approach for analysing the data collected. This is proving to be a positive approach with significant findings proving the set predictions. (Smallbone and Quinton, 2004). Measuring variables in the collection of data for social research has become a possibility through ranking of attributes from lowest to the highest level. No human being holds attributes in absolute terms, they hold the attribute in degrees from low to high or from negative to positive, and hence tools are made keeping the degree of attributes in consideration. And subsequently used. The attributes have to be checked for accuracy, validity, replicability and reliability. All these four very substantial checking steps must be present for all items of the measure to be used. If any of the checking step is missed then we cannot rely on the data collected, rating measures used should be accurate, they must be valid, i.e. repeatable in such situations whenever applied,, they must be able to be replicated in another research and they must be reliable, i.e. it must be a standard measure. A brief description of these four standardizing methods are given below.

5.2 Accuracy:

Without analysis data collection will not be proved significant or unsignificant. For this step one has to be sure that the information collected in the procedure of the data collection is rightly gathered, is giving the fairest rating to describe the issue. Data should be as honestly collected and subjects should give true views because otherwise data analysis will not give the correct picture and subsequently interpretation of data will also be questionable. And will lead to wrong conclusions. To apply accuracy source of data should be verified, edit the responses given by subjects. So that biases of any sort may be avoided. An analytical review published by the Colorado State University (1993-2016) defines Accuracy as a terminology used in survey research to refer to the match between the target population and the sample that is the parameters to be studied in the population is present in the sample taken from the population.

The findings are measured so rightly that they may be used for generalized views about attributes studied in the universe. By checking your data with other reliable sources from various angles one can become very sure about his data's accuracy. Accuracy refers to highest compatibility between measured data with standard view regarding the issue.

5.3 Validity:

A test measures what it says it is measuring. This is validity. This applies to equipment like thermometer, oximeter, and blood pressure machine. They measure the accurate level to depict if body is functioning normally or not. If it is not normal as indicated by your instrument than medical help may be taken to bring the levels of persons to the normal level. It is important because it gives the required information. Data collected using invalid instruments may not give similar results again, such instruments cannot be dependable, as there may be ambiguity. If used one may not be able to claim that results from the invalid instrument may not give results as predicted. Validity explains how well the collected data covers the actual area of investigation (Ghauri and Gronhaug, 2005). Validity basically means "measure what is intended to be measured" (Field, 2005). There are four main methods of assessing validity. These are face validity, content validity, construct validity, criterion validity. Meaning of these methods of validity are as follows. Face validity measures the appearance of the content of the test, looking at the items in the tool the experts may judge them to be right representation of the concept being measured, i.e. if attitude tool is made then the items of the tool must appear right for measuring Attitude.

Content validity measures the extent to which the tool contents are right for measuring the concept for which it is made, e.g. the attitude test must contain items which measure aspects of attitude only, and not something else. Construct validity mean the test measures the concept for which it is made, e.g. if it is an attitude measuring tool than it should measure attitude only.

Criterion validity method is used to judge if the new tool constructed is matching similar standard tool from the past. This is assessed by applying the new tool together with an old similar tool to the same group of subjects, if the scores of the two tools are correlating significantly, than the new tool is as valid as the old tool. In general, validity indicates how sound the research of the researcher is. More specifically, validity applies to construction of tool, to its application on the sample, proper analysis and proper interpretation.

5.4 Replicability:

A new researcher may want to use the previous research on some other sample somewhere else, than the new researcher should be able to get similar findings in new surroundings on a new population. This is replicable research, that is proof that the original research was valid. If so then the validity of the initial research is established. To replicate something lexically means to repeat it. The integrity and viability of a Research is in its capacity to be replicated. For example, if someone conducts first experiment and get finding significant at .01, than conducting the same study other person should also get significant finding as previously found, nor the validity will not be observed. Replicability has been interpreted by Lewis-Beck et al (2004).

The Author identified three key aspects to the concept of replicability: a finding being repeated in another research and giving similar findings, the second researcher working autonomously on the similar line of previous work and the use of valid, but different, methods for different aspects being studied in the new research.as replicability will refer to only the concept which has been repeated, not to other concepts studied in the same research The Author(s) further explain that to be considered valid, the group of researchers replicating the study need to be independent of the original researchers. "Independent" means that they have no reason not to be dispassionately objective in their attempts to replicate the findings. Those replicating the study should not be known to each other, professionally or socially.

The Authors most importantly assert that in order to take a scientific study or experiment seriously, the results need to be able to be proven multiple times by independent researchers. Research that has been shown to be replicable affords greater confidence in the results.

5.5 Reliability:

Reliability of the measurement tools should give consistent results on giving similar tests, or equivalent forms of test or same test again and again. i.e. it refers to the repeatability of findings. If the study were to be done a second time, it would it give similar findings. If so, the data depicts reliability. If more than one person observe an event or occurrence than all should observe similar findings. This will be proof about reliability of the study. Reliability may also be applicable to individual being measured more than once on any test. If he gets good scores on comprehension once than again on the test being repeated he should yield almost the same score on the test. Than the test is reliable. To be reliable, a tool being used for measuring some attribute should give similar score when administered twice on the same person after a short gap this will reinforce the findings and ensure that the wider scientific community will accept the hypothesis. Without this replication of statistically significant results, the experiment and research have not fulfilled all of the requirements of testability. This prerequisite is required to test any hypotheses and proving it to be true essential to a hypothesis establishing itself as an accepted scientific truth. Reliability is therefore the degree to which an assessment tool produces stable and consistent results and this can be further broken down into subdivisions (Sankale et al: 2015).

In conclusion, whereas reliability is necessary in research, reliability alone is not sufficient. If data is valid, it must be reliable. When a research produces very different scores on a test whenever it is conducted, the test is not likely to predict anything. On the other hand, if a test is reliable, that does not mean that it is valid. For a test to be reliable, it must also be valid. Reliability and validity are conceptualized as trustworthiness, rigor and quality in a qualitative paradigm. It is also through this association that the processes to achieve validity and reliability in research get affected from the qualitative.

Without measurement research is not fruitful, we cannot confirm our research findings with confidence. This highlights the role of measurement in all social science studies, and it is useful to prove that the various selections made in organizations on the basis of selection tools are worthwhile and are claiming to prove useful in all spheres where appropriate selection of employees have to be made, where decisions have to be made, and one cannot rely only on common sense.

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6. Steps Involved in Research Process

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6.1 Introduction:

The research process incorporates a series of steps to be followed for completing the research. All the steps usually are followed in a sequence starting from problem to be studied to review of literature uptill the preparation of report. These steps are exclusively mentioned while writing the report but they may merge in one another while the research process is followed. One should remember that the various steps involved in a research process are not mutually exclusive, nor they are studied one after the other. Separate and distinct.

Every step is the outcome of the previous step and while studing each step one may not be sure of where it may lead to. Every step is anticipatory. However, the following standard order of the various steps are pointed below in the model depicting steps involved in research process.
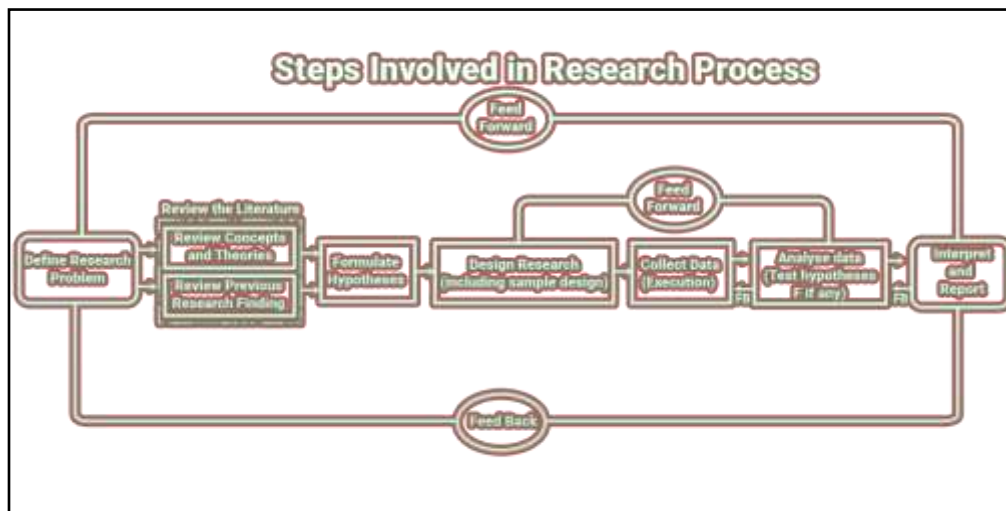
A. Research Problem Formulation: Research usually starts with a problem which researcher wants to study. They depict some gap in knowledge which has to be filled through the new research to be studied. This knowledge gap may relate to nature of the concept which poses a question or it may be related to assessing comparative relation between various concepts. Thus usually two types of research problems erupt, viz., those which relate to nature of variables to be studied and those which relate to relationships between variables.

First step to understand the problem to be studied is by consulting experts in those areas, discussing with experienced persons and if one has a guide one may discuss with the guide for gaining more clear view about the problem to study Often, the guide puts forth the problem in generalized terms and it is up to the researcher to pick up specific aspects from the generalized version and further study using empirical approach or operational approach. In private business units or in governmental organizations', the problem is usually earmarked to the related department with which the problem is concerned so that the researcher may discuss with the concerned Departmental head, who is an experienced person about background of the problem and how he may go about doing the research steps.

B. Extensive Literature Survey: A problem which researcher plans to study emerges from a lot of work done in the past related to the concern taken up. One should search for theoretical base as that is responsible for various factual information which one desires to study. Those factual data must have been studied from various angles by other researchers, all this comes in review of literature. This is the background against which the problem one plans to study reveals itself. This problem highlights the gaps still existing in the topic one is studying. Once the problem is chalked out a tentative plan of action may be identified. All this one presents as synopsis in front of the research committee which after studying and understanding one's topic, gaps planned for study, may decide whether there is anything unique in his research or it is not worth studying. Hence elaborate review of literature is demanded this is essential because lot of time is spent in research study and if the wrong topic is taken up than it will be a waste of researcher's efforts. Search of various books, Academic journals, annual reports, conference proceeding are essential for understanding the problem and how to study, etc. In this process, it should be remembered that one source will lead to another. A good library will be a great help to the researcher at this stage.

C. Construction of Working Hypotheses: On the basis of review of literature gaps in the research topic are highlighted. They lead us to the problem to be studied and how it has to be studied. Predictions are made which would be tested in the research. That leads us to the formulation of working hypotheses. These will give ideas about what aspects of the concept have to be researched and the direction in which these will be studied. Hypothses depict the relationships which will be studied in the research study or the impact which the independent variable will have on dependent variables. Working hypothesis is a predictive statement about the rationalized relationship which may become the outcome of the study. This give direction to the study. They also direct the roadmap for which dimensions will lead to what outcomes, what will be a comparative relation between various variables, etc. the major aspects of the study will be worked upon based on the hypotheses to be tested. This will also focus on sample to be studied, the way they will be incorporated in the study in order to make it possible to analyse the data rightly to prove the gaps which we are studying as significant or not. The development of the working hypothesis plays an important role in guiding researchers towards the outcomes predicted. Hypothesis should not be a general statements but it should specify the relationship or impact of the various variables which are assumed to be the outcomes which are predicted. Hypotheses should be limited to the variables in consideration as part of the research study. Hypotheses acts as a guide to the researcher by narrowing them down to the purpose for which they have been stated. One's cognitions are acutely directed in the direction towards the data analysis and ultimately to findings which may prove that the research study was serving the purpose for which it is being conducted.

D. Research Design formulation: After the research concept is decided upon, gap identified to be studied related to the problem, the researcher has to prepare a proper design for moving further in the right research direction. The research problem having been formulated in clear cut terms, the researcher will be required to prepare a research design. The preparation of the research design, appropriate for a particular research problem, involves usually the consideration of the following:

It is a model plan specifying the methods and procedures to be applied for data collection, editing and categorizing the collected data, conducting preliminary analysis, on the basis of the results found applying higher level analysis for clear cut testing of all the dimensions of the topic being studied, this will clarify the significance of the findings for assessing the gap studied.

This will be based on the method used for obtaining data and the expertise of the researcher. There are four basic research designs that a researcher can use to conduct his or her study;

a. Survey Method,
b. Experimental Method,
c. Subjective/Secondary data study, and
d. Observational Approach.

The type of research design to be chosen from among the above four designs depends primarily on four factors:

- The type of gap observed in the problem
- The objectives set in the study,
- The Research gap between present problem and what is predicted for future knowledge achievement.
- The time and finance required for study is available.

The selected method will be rationalized for its application, it's organization and further testing in future. Next aspect influencing selection of research design is the duration required for research completion and the finance required for doing it.

E. Determining Sample Design: The researcher must decide the way of selecting a sample of what is popularly known as the sample design. In other words, a sample design is a definite plan determined before any data are actually collected for obtaining a sample from a given population. These methods are basically of two types: probability sampling and non-probability sampling. Probability sampling ensures every unit of the population being may have a chance of being selected in the sample and being studied. Random method is used to collect data.

If the whole population is to be studied than anyone may be included in the sample, than a non-probability sampling method may be employed. This decision is based on researcher's ease of data collection and this is his choice based on what he wants to do. This approach is variously called judgment sampling, convenience sampling, accidental sampling, and purposive sampling.

The most widely used probability **sampling methods are simple random sampling, stratified random sampling, cluster sampling,** and **systematic sampling.** They have been classified by their representation basis and unit selection techniques.

Two other variations of the sampling methods that are in great use are **multistage sampling** and **probability proportional to size (PPS) sampling.**

Multistage sampling is most commonly used in drawing samples from very large and diverse populations. They may also be the steps of data collection and their findings respectively stage wise. The PPS sampling is a variation on multistage sampling in which the various units to be studied are selected on some criteria and then from each unit some percent of sample is selected as sample, example if we study two villages to differentiate than we may take 10%of sample from each village population, or if this is not feasible than a sample of 200 persons from each sampling areas are selected for data collection..

F. Collecting Data: The approach for data collection depends upon the objectives of the research study, the research design selected and the duration, finance and data collection skill. Based on all these aspects data may be accumulated by observation method, questionnaire method, or large scale survey. There are many ways of data collection, but will be governed by limiting factors mentioned above. Based on the type of data to be collected, i.e. qualitative or quantitative method the way of data collection is used.

The most prevalent method for collecting quantitative data is by self-administered questionnaires or structured interview methods. In present time telephonic interviews, questionnaires in Google forms are also used. These can easily be administered through internet usage and be reachable nationally and also internationally. The secondary data may be taken from such sources like census, official documents, past records, etc.

Qualitative data are collected mainly through **in-depth interviews, focus group discussions, KII,** and observational studies.

G. Data analysis: After Data collection, data is processed. Editing is done to check mistakes and to delete aspects which are useless. Next coding manual is prepared to decide how every data processing will be labeled, the whole data collected is put in orderly manner via coding before data is analysed. Data are edited to ensure consistency across respondents and to locate omissions, if any. Alphanumeric codes are used to reduce the responses to a more manageable form for storage and future processing. It is impractical to use raw data without putting it in appropriate order. Data analysis usually involves using statistical tools like SPSS or AMOS for analyzing the data collected and testing the significance of results with hypotheses made in the study. Further, the researcher, based on his analysis, determines if his findings are consistent with the formulated hypotheses and theories.

The techniques to be used in analyzing data may range from simple descriptive analysis till higher level multivariate analysis depending upon the objectives of the study. As in the case of methods of data collection, an analytical technique appropriate in one situation may not be appropriate for another. One should apply only that statistical method needed for testing the questions raised in the study.

H. Generalizations and Interpretation: After data analysis we check the findings with other researchers. If the research finding is also found by other research on this topic than generalizations may be drawn and they may contribute to emergence of a new theoretical base. This is generalization.

If the researcher had no hypothesis to start with, he might seek to explain his findings on the basis of some theory. It is known as interpretation. The process of interpretation may quite often trigger off new questions which in turn may lead to further researches.

This chapter imparts the eight steps which are included in the research process. All who conduct research or project work should use these standard steps for completing the research study correctly and coming up with findings which serve the purpose of the project or research study.

6.2 References:

1. Kothari, C. R. (2019) Research Methodology: Methods and Techniques (Multi Colour Edition). 1 September.
2. Md. Harun Ar Rashid | July 6, 2020 | Research Methodology. Steps Involved in Research Process:

7. Research Report Writing

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7.1 Introduction:

A research report is considered a major step of any research study as the research remains incomplete till the report has been presented or written. The straineous efforts of the research work which stretch over a long period, requiring enormous amount of studying, data collection, result analysis, interpretation, the findings of the research are of little value unless they are effectively documented and communicated to others The research report is written after the research is completed. In this all the steps used for research are elaborated upon with rationalization to make it understandable.

Reason for the research report is to circulate to interested persons about the steps involved in the research in a sequential manner with logics involved in each step to convince the readers about the rationalized presentation of the research study with final summary to give it a complete Project appearance.

Thus it is the last part of a research which compiles all the steps performed like gap in problem to be studied, hypothses formulations, research design, data collection, results and analysis and discussion and interpretation and final conclusion.

All this summation gives a complete look to the Research Reports Writing a research report is a systematic step by step presentation which incorporates lot of thinking, mental works, reading of lots of past resources, etc and then filling the gaps in problems found in a rational method with presentation in proper communicative language to make it appear as flawless as possible.

7.2 Types of Report:

Research reports are written differently in different subjects. On that basis the length and type of report is made. For example annual reports in tabular forms are common way of presentation in banks and other financial institutions.

In mathematics, many algebraic notations may be applied, in chemistry reports may include many form of symbols and formulae. Literature reports are usually description of generalizations derived from writings of writers.

Other examples of reports include book reviews, reports prepared by government bureaus, PhD theses, etc. Any research investigation may be presented in like a technical report, a popular report, an article, a monograph, or, at times, even in the form of an oral presentation

7.3 Writing the Research Report:

Once the data collection and analysis work is over, the researcher will start writing the research report. Social and development research reports need to have a logical, clear structure with the usage of simple language, and have an attractive appearance.

Just as an architect has to draw a framework for the house that is being designed, The researcher must sketch out the framework for your report. This framework includes a head, a body, and a tail. The head consists of a description of your problem within its context (the country and research area), this may be termed as synopsis or the preliminary pages. It incorporates the objectives of the study, gap in questions which are being studied and the hypotheses formed and the way in which analysis will be done. And the methodology followed. Just as head it is the first portion of the thesis and should not be very elaborate. The body will form the bigger part of your report: it will contain the basic results, hypotheses testing through statistical tools usage and the outcomes there in. research findings.

The tail, finally, consists of the discussion of the data collected and analysed by linking findings with results of other researcher's findings in the same area. This may prove whether the researcher's findings are unique or matching with other findings. Next will be conclusions, limitations encountered and recommendations.

Before research report writing starts researcher must match the data collected and analysed with the objectives which have been specified in the introductory phase. Check for any gaps which might be missed. Draw major conclusions and relate them with findings of other studies reviewed in the literature portion. One may also check the data collected in their primary form to check if anything is left out. Again, researcher may be propelled to do some more analysis to check some aspect missed out.

Apart from quantitative analysis qualitative data analysis may be done and conclusions drawn from them and may be tabulated or drawn in form of bar diagrams or graphs, etc.

After going through all these steps report writing may start. The research report will have, broadly, three parts.

Part I: The Preliminary Pages

Part II: The Main Text of the Research Report

Part III: The End Matter

Part I: The preliminary pages of the research report should have the following main elements.

Title and cover page: The cover page should contain the title, the names of the authors with their designations, the institution that is publishing the report with its logo, the month, and the year of publication. For e.g.

Effeminacy of Agriculture: Impact Analysis of Mahila Kisaan Sashaktikaran Pariyojana on Socio-Economic Status, Knowledge and Decision Making of Women.

- A foreword: Often, a foreword will tell of some interaction between the writer of the foreword and the story, and the writer of the story. It is written by some other person about the researcher or his views, etc.
- Preface: A preface, by contrast, is written by the author of the book. A preface generally covers the outline of the research presented.
- Acknowledgements: In this step the researcher thanks all persons who have played a role in his research conduct, analysis and writing. All persons who have been a support during the research completion process are shown gratitude.
- Table of contents: A table of contents presents the order in which the various phases of research are carried out, what are the numbers on which they are depicted in the thesis. It provides the reader a quick overview of the chapters with major sections and sub sections of the research report, and page references, so that the reader can go through the report as per his requirement. The sections and sub sections within each chapter may be given numbers that are specific to the chapter
- List of tables: If there are tables in the research report than they should be presented in tabular form revealing the pages on which the tables and their descriptions are provided. It is essential to list these also in the table of contents formatted with page numbers. The initial letters of the key words in the title are capitalized and no terminal punctuation is used
- List of figures: The list of figures appears in the same format as the list of tables, together with the titles applied to them.
- List of appendices: Appendices are presented after the complete report is written including questionnaire, a letter of appreciation, a government notification, the list of appendices appears in the same format as the list of tables.
- List of abbreviations: If abbreviations or acronyms are used in the report, these should be stated in full in the text the first time that they are mentioned. If there are many, they should be listed in alphabetical order as well. The list can be placed before the first chapter of the report. The table of contents and lists of tables, figures, abbreviations should be prepared last, as only then can you include the page numbers of all chapters and sections, sub-sections in the table of contents. Then, you can also finalize the numbering of figures and tables and include all abbreviations.
- Executive Summary: The summary will be the first (and for busy programme manager/decision makers most likely the only) part of your study that will be read. The summary should be written only after the completion of research. It should contain a bird eye view of the research work i.e. a very brief description of the problem (Why this study was needed) - the main objectives (What has been studied) the place of study (Where) the type of study and methods used (How) the major findings and conclusions • the major (or all) recommendations. Therefore, it demands thorough reflection and is time consuming. Errors should not be there. Writing should be clear, language should be appropriate to understand. Several drafts may have to be made, after discussing the previous one with your seniors or guide. As you may have collaborated with various groups during the drafting and implementation of your research proposal, you may consider writing different summaries for each of these groups. For example, you may prepare different summaries for policymakers and programme managers, for

implementing staff of lower levels, for community members, or for the public at large (newspaper, TV). In a later stage, you may write articles in scientific journals. In this section, we discussed about the types of report and the contents to be included in the preliminary pages of research report.

Part II: The Main Text includes the following chapters • Introduction • Review of Literature • Methodology • Research Findings • Discussion • Conclusion and Recommendations • Summary

Chapter 1: Introduction:

The introduction includes discussion of the concept which is being studied in the research, it should contain the nature of problem, why it is an issue for study. What are the relevant environmental/ administrative/ economic/ social) background data and information about the topic on which you are carrying out research. It can be drafted after understanding the concept yourself (for example if you are doing research on higher level education, then a brief about the value of higher education, Where are they being provided, how many are there in one state, what is the reason for enhancing higher education, How much expenditure is occurring on higher education, on the basis of research what will be the advantage for society, etc. You may make additions to the corresponding section in your research proposal, including additional literature, and use it for your report. Then, the statement of the problem should follow, again, after referring to report writing proposal that will make it more relevant. With additional comments and relevant literature collected during the implementation of the study. It should contain a paragraph on what you hope/ hoped to achieve from the results of the study. Enough background should be given to make clear to the reader why the problem was considered worth investigating. The general and specific objectives should also be included in this chapter. If necessary, you can adjust them slightly for style and sequence. However, you should not change their basic nature. If you have not been able to meet some of the objectives of the project, this should be stated in the methodology section, and in the discussion of the findings. The objectives form the heart of your study. They determined the methodology you chose and will determine how you structure the reporting of your findings. 5.5.2

Chapter 2: Review of Literature:

Global literature can be reviewed in the introduction to the statement of the problem if you have selected a problem of global interest. Otherwise, relevant literature from individual countries may follow as a separate literature review after the statement of the problem. A literature review is a body of text that aims to review the critical points of current knowledge and or methodological approaches on a particular topic. Literature reviews are secondary sources, and, as such, do not report any new or original experimental work. Its ultimate goal is to bring the reader up to date with current literature on a topic, and forms the basis for another goal, such as future research that may be needed in the area. A well-structured literature review is characterized by a logical flow of ideas; current and relevant references with consistent, appropriate referencing style; proper use of terminology; and an unbiased and comprehensive view of the previous research on the topic. One research study should be presented in one paragraph and it should mention the name of the researcher, year of study, topic and area of study, sample size, main objectives, and findings of the study.

Chapter 3: Methodology:

The methodology adopted in conducting the study must be fully explained. The scientific reader would like to know about the basic design of the study, the Data Collection and Analysis methods of data collection, information regarding the sample used in the study, the statistical analysis adopted and the factors limiting the study .The methodology section should include a description of • the study type • major study themes or variables (a detailed list of variables on which data was collected may be annexed) • the study/ target population(s), sampling method(s) and the size of the sample(s) • data collection techniques used for the different study populations • duration of data collection • how the data was collected and by whom • procedures used for data analysis, including statistical tests (if applicable) • any constraints and its management • limitations of the study. If you have deviated from the original study design presented in your research proposal, you should explain to what extent you did so, and why. The consequences of this deviation for meeting certain objectives of your study should be indicated. If the quality of some of the data is weak, resulting in possible biases, this should be described as well under the heading 'limitations of the study'.

Chapter 4: Research Findings:

A detailed presentation of the findings of the study with supporting data in the form of tables and charts, together with a validation of the results is the next step in writing the main text of the report. The result section of the study should contain the statistical summaries and reductions of data, rather than raw data. All the results should be presented in a logical sequence and split into readily identifiable sections. The systematic presentation of your findings in relation to the research objectives is the crucial part of your report. The list of data by objectives will help you to decide how to organize the presentation of data.

The decision concerning where to put what can best be 97 made after all data have been fully processed and analysed, and before the writing Report Writing starts.

When all data have been analysed, a detailed outline has to be made for the presentation of the findings. This will help the decision-making on how to organize the data, and is an absolute precondition for optimal division of tasks among group members in the writing process. At this stage you might as well prepare an outline for the whole report, taking the main components of a research report as a point of departure.

An outline should contain • the headings of the main sections of the report • the headings of subsections • the points to be made in each section • the list of tables, figures and/or quotes to illustrate each section. The outline for the chapter on findings will predictably be the most elaborate. The first section under findings is usually a description of the study/ target population. When different study populations have been studied, you should provide a short description of each group before you present the data pertaining to these informants.

Then, depending on the study design, you may provide more information on the problem you studied (size, distribution, characteristics). Thereafter, in an analytic study, the degree to which different independent variables influence the problem will be discussed.

Chapter 5: Discussion:

The findings can now be discussed by objective or by cluster of related variables or themes, which should lead to conclusions and possible recommendations. The discussion may also include findings from other related studies that support or contradict your own. Discussion may relate the research findings with other studies linked with the present research and whether it relates significantly to the findings of the results or not, and what may be the cause of such findings.

Chapter 6: Conclusions and Recommendations:

The conclusions and recommendations should follow logically from the discussion of the findings. Conclusions can be short, as they have already been elaborately discussed in Chapter 5. As the discussion will follow the sequence in which the findings have been presented (which in turn depends on your objectives) the conclusions should logically follow the same order. Sometimes, it is advisable to present conclusion and recommendations in specific sections related to issues of importance/under investigation/objectives of the study for better clarity to different stake holders. The conclusions should be given in bullets so that it can easily catch the attention of the reader. Remember that action-oriented groups are most interested in this section.

The conclusions should be followed by suggestions or recommendations. While making recommendations, use not only the findings of your study, but also supportive information from other sources. The recommendations should be generated from the findings and conclusions. It should not be generalized; rather it should be specific to particular stake holders in pure, actionable term which is feasible in relation to social context, policy and constitution of country, political acceptability, budget, time, etc. One should not give general recommendations such as, "Government should provide free treatment to everyone for all health problems".

If your recommendations are short (roughly one page), you might include them all in your summary and omit them as a separate section in Chapter 6 in order to avoid repetition. 5.5.7

Chapter 7: References:

This is the list of books/articles in some way pertinent to the research which was followed while conducting research. It should contain all those works which the researcher has consulted. The references in your text can be numbered in the sequence in which they appear in the report and then listed in this order in the list of references (Vancouver system). Another possibility is the Harvard system of listing in brackets the author's name(s) in the text, followed by the date of the publication and page number, for example: (Sharma et. Al., 2000: 84). In the list of references, the publications are then arranged in alphabetical order by the principal author's last name. You can choose either system as long as you use it consistently throughout the report unless some guidelines specifically ask for it (in case of research publications). The references should be given in the following order. 1) Name of the author, last name first. 2) Title, underlined to indicate italics. 3) Place, publisher and date of publication. 4) Number of volumes.

Chapter: 8 Annexure:

The annexes should contain any additional information needed to enable professionals to follow your research procedures and data analysis. Information that would be useful to special categories of readers but is not of interest to the average reader can be included in annexes as well. Examples of information that can be presented in annexes are • tables, figures (graphs) and pictures referred to in the text but not included in order to keep the report short • lists of hospitals, districts, villages, etc., that participated in the study • questionnaires or check lists used for data collection • A list of research team members.

Note: Never start writing without an outline.

Style and Layout of the Report:

The style of writing and layout of writing are two important components of report writing. However, revising and finalizing the text may also be considered as another important aspect in same line.

Style of Writing Remember that your reader is short of time has many other urgent matters demanding his or her interest and attention is probably not knowledgeable concerning 'research jargon'. Therefore, the rules are easily understandable simple style.

Keep to the essentials:

Give rationalization for what you have done. Don't use common sense information, it should be based on facts and theories studied and referred. Do not quote the name of anyone who has provided the information in Report Writing In case of sensitive findings, one should not mention name of village/ location, etc. Quantify when you have the data to do so; like 50%, don't say less or much, large or small be precise and specific in your phrasing of findings.

Ude fact based information, - avoid exaggeration

Use brief sentences

Use adverbs and adjectives seldom, only objective facts should be presented

Be consistent in the use of tenses, like past, presnt, etc.

Avoid the passive voice, as it creates vagueness (e.g., 'patients were interviewed' leaves uncertainty as to who interviewed them)

Aim to be logical and systematic in your presentation.

Layout of the Report

A good physical layout is important, as it will help your report

- Make an impressive start.

Motivate readers to read and show their interest in what they want to read first. Particular attention should be paid to make sure there is

- An attractive layout for the title page and a clear table of contents
- Consistency in margins and spacing
- Consistency in headings and subheadings, e.g.: Font size 16 or 18 bold, for headings of chapters; size 14 bold for headings of major sections; size 12 bold, for headings of sub-sections, etc.
- Good quality printing and photocopying
- Correct drafts carefully with spell check as well as critical reading for clarity by other team-members, your facilitator and, if possible, outsiders
- Numbering of figures and tables, provision of clear titles for tables, and clear headings for columns and rows, etc.
- Accuracy and consistency in quotations and references.

Part III: The End Matter

Revising and Finalizing the Text.

Prepare a double-spaced first draft of your report with wide margins so that you can easily make comments and corrections in the text. Have several copies made of the first draft, so you will have one or more copies to work on, and one copy on which to insert the final changes for revision.

When a first draft of the findings, discussion, and conclusions has been completed, all working group members and facilitators should read it critically and make comments. The following questions should be kept in mind when reading the draft. Have all important findings been included?

- Do the conclusions follow logically from the findings? If some of the findings contradict each other, has this been discussed and explained, if possible? Have weaknesses in the methodology, if any, been revealed?
- Are there any overlaps in the draft that have to be removed?
- Is it possible to condense the content? In general a text improves by shortening. Some parts less relevant for action may be included in annexes. Check if descriptive paragraphs may be shortened and introduced or finished by a concluding sentence.
- Do data in the text agree with data in the tables? Are all tables consistent (with the same number of informants per variable), are they numbered in sequence, and do they have clear titles and headings?
- Is the sequence of paragraphs and subsections logical and coherent? Is there a smooth connection between successive paragraphs and sections? Is the phrasing of findings and conclusions precise and clear?

The original authors of each section may prepare a second draft, taking into consideration all comments that have been made. However, you might consider the appointment of two editors amongst yourselves, to draft the complete version. The help from proof readers may also be taken to remove minor mistakes from the draft. It is advisable to have one of the other groups and facilitators read the second draft and judge it on the points mentioned in the previous section. Then a final version of the report should be prepared. This time you should give extra care to the presentation and layout: structure, style and consistency of spelling (use spell check!). Use verb tenses consistently. Descriptions of the field situation may be stated in the past tense (e.g., 'five households owned less than one acre of land.'). Conclusions drawn from the data are usually in the present tense (e.g., 'Food taboos hardly have any impact on the nutritional status of young children.)

Common Weaknesses in Report Writing and Finalizing the Text:

It is important to know the general mistakes committed in report writing and also the points to consider while finalising the text.

A. Endless Description without interpretation: Often tables are given without any interpretation. That is a waste. Please always relate tables with findings and what they mean. Tables need conclusions, not mere detailed presentation of all numbers or percentages in the cells which readers can see for themselves. The chapter discussion, in particular, needs comparison of data, highlighting of unexpected results, your Report Writing own or others' opinions on problems discovered, weighing of pro's and con's of possible solutions. Yet, too often the discussion is merely a dry summary of findings.

B. Neglect of Qualitative Data is also quite common. Quotes of informants as illustration of your findings and conclusions make your report lively. They also have scientific value in allowing the reader to draw his/her own conclusions from the data you present. (Assuming you are not biased in your presentation!). Presentation of important photographs also makes report attractive and explains facts better.

C. Sometimes qualitative data (e.g., open opinion questions) are just coded and counted like quantitative data, without interpretation, whereas they may provide interesting illustrations of reasons for the behaviour of informants or of their attitudes. This is serious maltreatment of data that needs correction. In these sections you have read about the main text and end matter of the research report. You have also read about the style and layout of the research report. The general mistakes committed while writing a research report and the method of finalizing the text have also been given.

D. All the aspects presented in Report writing should be taken seriously for making a good research and presenting it in appropriate styles.

8. An Overview of Format Analysis of Technical Reports

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8.1 Introduction to Technical Report:

A final document providing the facts on a task or exercise is defined as a report. As an R & D report, the research and development research results or progress are presented. A report is organized, objective, and factual information produced by an experienced or gathered person (information) and sent on to a person or persons who are in need or who wants it or who are entitled to it. Usually a technical report is more thorough than an article in a journal or paper at a conference. It includes adequate data to allow a reader to evaluate the original study or development research process. It is a final product of research, survey, research, etc.

In recent years, the technical report, the primary means of recording R&D effort, has become an important source of information. This is mainly due to the time-consuming publishing processes of newspapers and their desire for published research in progress.

However, many times it does not require extensive distribution of the nature of communication and so a technical report is produced. In addition, government-funded research results are often covered by secrecy and national security in the areas of space, nuclear science and defence, and are thus circulated to extremely limited people.

These factors led to the birth, in various forms and formats, of the technical report. Their objectivity and targeted audience characterize the technical reports. They define the problem, analyse and evaluate existing and future circumstances and describe methods for problem solving. Talk about the results, draw conclusions and recommend further action.

For many purposes, a technical report is written. Project proposals are submitted for grants: regular reports on the situation and progress of projects are prepared to inform the management of latest developments in the specific field; technical papers are issued to provide information to the outside world and to those working in the field about new findings, etc.

The project proposals are submitted to the project management for grants. Whatever the form of the report is, it shall be produced with three major purposes: (a) informing the reader on the study result, (b) recording the research results and posterity test results, and (c) recommending a true course of action to be taken. Although the computer and DTP techniques are a significant improvement for the technical report late, the typed report can be very frequently duplicated/mimeographed. Limited copies are generally created for circulation (not more than 50 in most situations). However, many reports are issued in considerable quantities. Although a tiny percentage of reports are published in publications, most reports are published in mostly journals, congresses or symposiums, books etc.

8.1.1 Write a Technical Report:

A technical report shall be published on the basis of existing fundamental knowledge, the technical details of development efforts related to the establishment of a particular artificial device/product. While regular research reports focus on the technical features during the development process, either pure research material or both research and development (R&D) components with an emphasis on research results. Certain fundamental research sections are limited and partially examined in technical reports, but can be ultimately used for future studies. The editorial decision to classify a manuscript as a technical report shall be taken on an individual basis.

8.1.2 Characteristics (TRs vary greatly): Technical reports:

- May contain information, design criteria, techniques, literature reviews, research history, extensive tables, pictures, explanations of failing approaches.
- The equivalent journal literature may be published before; more or different details may be provided than its later journal article.
- May have less background information because the sponsor knows it already
- Could have limited access
- Export-controlled and classified reports
- Can include obscure acronyms and codes for information identification

8.1.3 Form of a Technical Report:

Typically there are five to eight two-column pages in a technical report. Similar to ordinary research papers, technical reports may be organized to include the following components in the article "How to write a regular paper" publisher of the AU J.T. issue of 13(3) January 2010:

- Title, not greater than 75 features;
- Author(s) full name(s), no title(s) available;
- The first author's affiliation and email, and the additional authors' emails (if any, affiliations and e-mails) with the same affiliation as the first author should be included in the footnote;
- Abstract (not above 200 words but 100 words);
- Keywords;

- Introduction to the value of information reported for practice not exceeding one page;
- Report body;
- Conclusion;
- Acknowledgements (optional);
- Report body;
- Appendix references; (optional).

The technical report may however have certain special organisations, based on the technical work carried out, for the respective portions of the report which may be made up of multiple sections. Such a system should be rational, and can be achieved using a simple typeface and an appropriate technical phrase. The text should be logical. In order to create the topic logically, the parts should have coherent content. In one or more Appendices, information that does not suit the subject should be included.

The following is a list of sample sections which may be placed in the report body:

- Technical basis, comprising literature review, description and development of the initial problem and its basic needs and existing remedies;
- Motivations and reasons for the choice of design;
- Methods, design or layout suggested;
- Base, major implementation features;
- Selection of setup or method of measurement;
- Evaluation of performance, comparison, debate and analysis of the results gained.

When analysing the language aspects of technical reports, readability is an important need. The creation of succinct and straightforward phrases with short words and active verbs optimizes the writing process and enables more information to be included.

8.1.4 Types of Report:

The length and type of research reports vary widely. For example, for their annual report, the banks and other financial organisations choose short-state tabulations. In mathematics, there may be many algebraic notes on the report, whereas symbols and formulas can be used in a report by chemists. Literary students frequently prepare a long paper that analyses a writer or book critically.

The news items in newspapers are also a way of writing reports. Others include book reviews, state-owned reporting, doctoral theses, etc. Either a technical report, a public report, a paper, a monograph or even an oral presentation can be delivered to any research. The technical report will be developed for experts interested in the technical procedure and the terminology used in the project. The report is being written in technical jargon. The main emphasis in the technical report is on: I the methods employed; (ii) the assumptions taken throughout the investigation; and (iii) full presentation of the findings with their limitations and supporting information.Popular data are intended for people whose interest in research methods and study conclusions is limited in technical areas. Lay people and even top managers will be present at the audience who demand concise reports.

The popular report stresses simplicity and appeal. Clear writings, a reduction on technical detailed, particularly mathematical specifics, and the liberal application of diagrams should be pursued for simplification. Another quality of a popular report is its attractive layout together with huge printing and many subheadings. In such a report practical issues and political implications are highlighted.

A. Writing Research Report:

The researcher begins drafting the research report once data collecting and analysis work is done. Research reports on social and development need

- Have a clear and logical structure
- Just get there.
- Use simple language and have a good design

Just like an architect needs to set up a design plan for a designed house, you need to first outline your report. There's a head, a body and a tail in this contour. The head is a description of your topic (country and research) in its context, the aims of the study and the methods used. This portion of the report should not be more than a quarter, else it gets highly weighty. The body is the largest portion of your report: it contains results from research. Last but not least, your data, conclusions and recommendations will be discussed.

It is important to group and review your analysed data by objective before you begin writing. Verify if in fact all data are processed and analysed as anticipated in the appropriate approved study protocol / proposal. Draw important findings that relate to the literature of study. You might again be encouraged to revisit your raw data and refine your analysis, or to look for more literature to answer problems that can be brought about from the study of your data. Compile the main findings and quotations from the qualitative data for each particular purpose. You are preparing the report now.

Three parts will, in general, be in the research report.

Part I   :   The Preliminary Pages

Part II   :   The Main Text of the Research Report

Part III   :   The End Matter

B. Content of a Technical Report:

There must be a precise and extensive description of the models, methods, and components used for the design of artificial devices. The aim of the published subject is not merely to inform the development and priority of the prototype, but also to allow other professionals to replicate and test the prototype. A few practical factors are: application of the equipment, optimal modular design and reduced implementation costs. A technical work covering several aspects of the particular development effort and exceeding substantially the size constraints of an individual contribution can be separately published into two or more

sections. Sometimes a typical research paper contains the research parts of a study and the applicable aspects of the study can lead to a technical report. An Addendum can summaries partial new enhancements to the technical contribution that has already been published. An essential aspect of the technical report is a section that examines the balance between the independence and interdependence of factors involved in the execution of the application presented.

This part also describes the unpredictable challenges found, provides interim results and work on lesser-known factors. Depending on the amount of the graphical information, technical reports may occasionally contain up to 10 pages. Large figures with complicated block diagrams, flow charts and electrical circuits may finally extend across a whole page if figure features can be easily seen and properly described. If a large technical illustration in a single graph cannot be provided, a modular method is recommended. Additional figures showing the internal structure of each block should be followed by a reduced block design. Important components and interconnections introduced by the author(s) for the first time should be emphasized and detailed. The joint presentation of several data series in one graph is better suitable for comparison and analysis rather than the drawing of a separate graph for a specific data series. When numerous orders of magnitude differ across the numerical ranges of the data series, a logarithmic scale must be chosen for the corresponding axes. The number of figures, tables and textual contents need to be balanced. Whenever a number of figures or tables are required, an Appendix shall be appended. While the mathematical content of an application generally confined to existing equations, it is sometimes necessary to derive completely or partially less known or new analytical expressions.

In such circumstances it is convenient to provide in a separate appendix the series of equations following the ultimate outcome. For publishing in the journal, technical reports are covering a wide variety of topics including but not limited to:

- Development problems, sustainable social development through innovation and the development of an autonomous economy;
- Management of technology; biotechnology, poverty eradication;
- Health technology, life-saving equipment, prevention of diseases, telemedicine;
- Environmental problems, conservation of nature;
- Management of disasters;
- New knowledge, training and new technologies
- Information technology and communication (ICT);
- Scientific and technological e-learning;
- Transition to a knowledge-driven society and world peace from technology to cyber technology.

8.2 Format Analysis of Technical Reports:

Whatever the arrangement of the basic elements, the letter of transmission, cover and titles, summary, should be provided in a professional technical report. Otherwise abstract. Content table, photo list, and introduction. Materials and techniques, results analysis, conclusions. Recommendations, Recognition. Appendices & symbols, bibliography and references used in the report. In this section, some of these factors are explored briefly.

8.2.1 Letter of Transmittal:

This is a correspondence that sends the report to someone (typically a letter). It can include the title of the report, an overview of the scope and goal of the report, explanations of fixed issues, wherever possible (for example, unavailability of facilities which might have delayed the project), as well as acknowledgment.

8.2.2 Preliminary Material:

This includes title page, preface, if any, abstract or executive summary, content table, illustration list, tables etc.

8.2.3 Title Page:

First in a technical report is the title page. The title, date, institutional information and the like is included. Note that the title page text is not contributed to a report word count.

8.2.4 Cover and Title:

For technical reports, a simple, straightforward page cover and title arrangement is used. Sometimes, for all reports, an institution utilizes the same sort of cover layout (for example NASA, RAND Corp, etc.). Thus, once the different layout is seen, the reader is able to recollect and connect the institution.

The title page provides bibliographical data such as author(s) tittle names or the address (es), the contracting agency(s), publisher(s) or issuing authority, the issue of month and year 6f. Many reporting agencies, such as NASA, NTIS, etc. employ a unique report number for each and every report. Every report uses one report number. This number is shown both on the cover pages and the title pages. If the reader provides correctly this report number, most reports can be discovered through the library. The readers will be impressed by an attractive well balanced title page.

8.2.5 Preface:

The project leader or the head of the establishment normally writes this and contains the history of the project. This shall be excluded if the document provides a lengthy introduction with the genesis of the project.

8.2.6 Table of Contents:

The index lists all sections of the titles and the pages they begin with. The content page provides an overview of the organisation of the report, the depth and focus of the topic being addressed. Only two layers in the content are used when a report is substantial. The division levels, subdivision levels etc. are maintained by indentation, numbering or typography ales (caps, bold, italics, etc.). All figures, flowcharts and tables in the report are listed in the illustrations.

8.2.7 Abstract:

An abstract is called a brief description of the contents of a document. Before attempting to read the entire book, a reader is consulted and hence should stand alone. Informative and indicative abstracts are two types: As the name suggests, the previous document is usually brief in length (15words). The latter is long (250 words) and contains, albeit briefly, the methodology, results and main conclusions.

8.2.8 Summary:

Summary is a re-evaluation of a document's principal findings and conclusions. It is placed after the body content and aimed at enabling readers to understand and examine the text. The summary is, however, presented before the body's material in the technical reports. The problem, aims, key facts, conclusions and recommendations should be summarized. Executive summary, supplied with a report sometimes, is an information digest that provides important information that generally helps to make decisions. These include the financial, material and infrastructure implications, major findings and further recommendations.The abstract and the summary should help readers in finding out whether the document is relevant and in determining whether the document is to be read, keeping up to date on current developments and obtaining an overview of the document.

8.2.9 Body of the Report:

The main body of the report is the introduction, materials and methods, the data analysis, the results debate, the conclusions and recommendations.

8.2.10 Introduction:

The reader is guided by the contents of the report in this important part. A brief literary survey, objective statements and scope are included. The status of the continuing study on the subject is determined by a cursory examination of literature. If the report deals with experiment, the materials and procedures are discussed in full, including alternative methods. The method used for the survey and the reasons why the method is selected should be stated if surveys, investigations etc. are included in the report, the nature of the population. The data collected throughout the investigation are analysed according to several statistical principles. While the purpose and aim of the report are clearly indicated in the objective statement, it does expose the subjects and bounds of the study. The approach indicates how the study has been conducted or followed to achieve the goals of the report. This section follows the problem and background information, which gives the reader an overview of the situation and the conditions underlying it. The reader is detained and a well-written introduction sets the tone, subject and its limitations.

8.2.11 Conclusions and Recommendations:

The judgments and recommendations are developed on the basis of analyses and facts. This section highlights the most important and important statistics and thoughts presented in the report. All conclusions should therefore relate to the facts and data in the report.

The results should be briefly written without long comments. The major recommendations are clear when the results are explicit and straightforward. Each recommendation is numbered and the first one should address the problem and the solution of the report.

8.2.12 End Material:

The end-material shall be considered acknowledgment, references/bibliography, abbreviations and appendices included in the report.

8.2.13 Acknowledgements:

While writing the technical report, the author receives support from various sources. These include donations from parent and other collaborative institutions, materiel, infrastructure and laboratory installations, beneficial discussions with colleagues, peer improvement ideas, and assistance from staff to data collecting or analysis, type-in, etc. All recognition may be grateful to the author for while writing the technical report, the author receives support from various sources. These include grants from parent or other collaborating institutions, materials, infrastructures and laboratory facilities, valuable talks, proposals for development by employees and support from staff in the gathering or analysis of data, typing etc. The author may desire to thank all people who have assisted, which are included in the recognition. However, only those who have actually and significantly involved to the drafting of the report are to be considered carefully.

8.2.14 References:

A scientific study is based on published material used in the development of problems. These intellectual obligations are paid via references and quotes (in text) (at the end). A bibliography is sometimes proposed by the authors for further reading. While all of the sources indicated in this report are necessarily consulted, throughout the preparation of the report the sources listed in the literature do not necessarily need consultation. Later on the citation and listing of references is discussed in a section.

8.2.15 Abbreviations:

At a single place, generally at the end, abbreviations are shown. The author should however maintain their use to a minimal and avoid utilizing acronyms or symbols which are not common and non-standard.

8.2.16 Appendices:

Supportive material such as legislative laws and acts not included in this text but needed to understand the concepts more effectively: long, complicated tables, flow charts and questionnaires which have no influence on the reader's understanding of the report; computer algorithms, long excerpts of other reports, notes, glossaries and mathematical proof that has been used. The inclusion of these in the text is thought to distract the reader's attention and hence is removed from the main text.

These must, however, be maintained to a minimum: otherwise it would be interpreted as having very little information in the original report. The finest written report, which has a few or no appendices, should be borne in mind.

8.3 Suggestions for Preparing References:

Citing and listing references would be standardization practice for authors, readers, and librarians alike. To retrieve knowledge efficiently and unequivocally. The following guidelines are presented to arrive at a standard style of references

a. If the title of the document to be mentioned (e.g. journal article, paper from the proceedings, book chapter, report title, etc) is not included, it would not be served as the prime purpose for providing the reference. It is important to decide promptly whether or not the work cited should be consulted.
b. The references would be unambiguous by dividing them into suitable groupings or sections, say three or four. Author/editor(s) of the document cited: title, journal, volume(issue No), year of parenthesis publication, inclusive page/conference/sympo nomination, place, month and year; title of the original work and editors name (for composite books, in this case); publisher, year etc.; title(s) of the cited document; name of the cited document. Publisher(s) of the original work, volume (issue No).
c. The information concerning the size of the document mentioned in terms of pages is also provided by inclusion pagination. It helps the user as the librarian in calculating the cost in case the document is to be procured from a copy supply facility such as INSDOC or BLDSC.
d. It would be simplistic and also simple to use the upper and lower types for the name of the author.
e. Giving imprint information in parentheses prevents confusion with the conference/site symposium's and year of references.

8.4 Bibliographical Control of Technical Reports:

Reporting literature is not easily accessible. "Grey Literature" is called for technical reports. That's because, contrary to books and newspapers. For reports there is no adequate bibliographical monitoring method. The nature of a classification of content security as limited, confidential and secret also raises issues that make some of them inaccessible. In certain areas of research & development (for instance defence, space, atomic energy etc), the government policy (or sponsorship agency) does not allow business bodies to publish or disseminate studies on certain subject areas. Very little additional information on the existence of a report is available. Further compounding the problem is the enormous number of reporting agencies.

It has become too tough to obtain technical reports due to all these variables. These reports are not readily provided by a seller. The scene has recently changed with the coverage by technical reports in abstracting and indexing periodicals, including the Scientific & Technical Aerospace Reports (STAR), the International Aerospace Abstracts (IAA), the Government Reports Announcements & Index (GRAI) and the Nuclear Science Abstracts (NSA) government reports, as well as inadequate coverage, to a limited extent, of biological

abstracts and chemical abstracts. National bibliographic control agencies (for example, the British R&D reports of the British Library Documents Supply Centre (BLDSC)) have recently published their exclusive R&D reports. While there may well be bibliographical controls and technical reporting in India (UK: BLDSE: USA: NTIS & UMI: CANADA: CISTI) there is no central agency to meet the user's needs.

Although it has been proposed to build a national document delivery centre for technical reporting, no measures have yet been adopted. The Science and Technology Department nevertheless strives in this area to provide reference tools. Because literature from the technical report can support better cross-fertilization by industry in overcoming the technological gap, a national bibliographical control and reporting centre is very necessary.

8.5 References:

1. IGNOU. ML1S course material on technical writing Block 3: Structure and functions or technical communication. IGNOU. New Delhi. 1995
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9. An Overview of Methods of Data Collection

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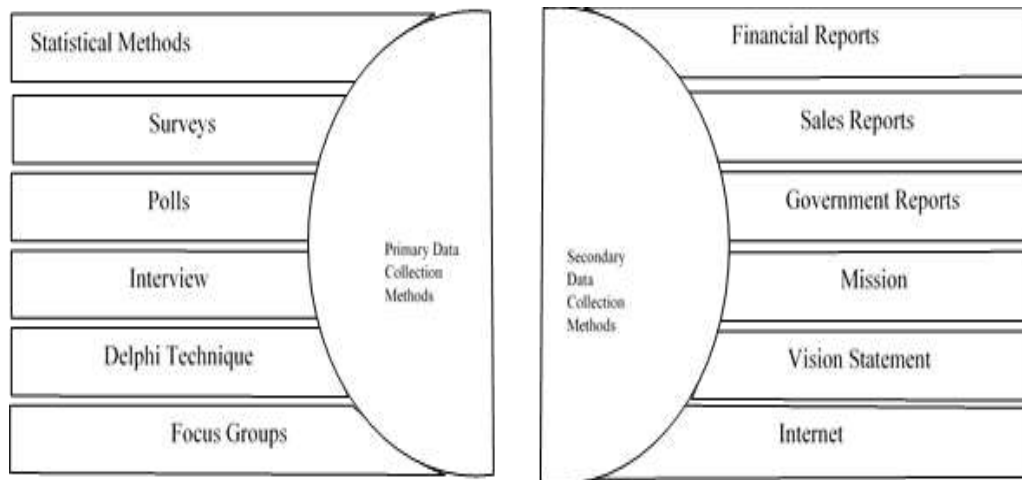
9.1 Introduction of Data Collection:

Data is a collection of data collected from various sources, figures, objects, symbols and events. In order to make better decisions, organisations collect data. Without data, organisations would find it difficult to make appropriate decisions, so that data from various audiences are collected at different points in time.

An organisation needs to collect data about product requests, customer preferences and competitors before, for example, a new product is launched. If data are not collected earlier, the newly launched product of the organisation may lead to a failure for many causes, such as lower demand and failure to meet customer requirements.

Data collection is the collection and measurement process of data on variables of interest, in an established system that allows one to answer questions, test hypotheses and evaluate results from research. In all areas of research, data collection is commonplace in physical and social sciences, science, business, etc.

The emphasis on guaranteeing an accurate and honest collection remains the same, although methods vary by discipline. The objective of the collection of all data is to obtain quality evidence, which then results in a comprehensive data analysis and enables a persuasive and credible response to questions.

In order to preserve the integrity of research, accurate data collection is essential, regardless of the field of study or preferences for defining data (quantitative and qualitative). The selection (present, modified or newly developed) of appropriate data collection tools as well as clear guidelines on how to use them correctly reduces the probability of error.

Statistical Methods		Financial Reports
Surveys		Sales Reports
Polls	Primary Data Collection Methods	Government Reports
Interview	Secondary Data Collection Methods	Mission
Delphi Technique		Vision Statement
Focus Groups		Internet

Figure 9.1: Concept of Data Collection

The collection of data is one of the most important phases of research. You can have the world's best research Design, but you will not be able to complete your project unless you can collect the necessary information. Data collection is a very demanding task that requires careful planning, hard work, patience, perseverance and more to successful completion. The collection of data begins with determining what type of data is required and the selection of a specimen from a particular population. Then you have to use a specific tool to collect the data from the sample selected.

9.1.1 Types of Data:

Two broad categories are organized in the data: qualitative and quantitative.

A. Qualitative Data:

Qualitative information is mainly non-numerical and usually descriptive or nominal. This means that the information is collected in words and phrases. Such information often (not always) captures the feelings, emotions or subjective perceptions of something. Qualitative approaches address the program's 'how' and 'why' and tend to explore the subject by using unstructured data collection methods. Qualitative matters are unresolved. Qualitative approaches include focus groups, group debates and interviews. Qualitative approaches are good for further study of the program's effects and unintentional consequences. However, they are expensive and time-consuming. Furthermore, the results cannot be generalised to participants outside the programme and are only indicative of the group. Qualitative methods of data collection play an important part in impact assessments by providing useful information to understand the processes behind observed results and to assess changes in people's understanding of their welfare. Moreover, qualitative methods can be used to improve the quality of quantitative assessments based upon the survey through the generation of assessment hypotheses; strengthen the design of survey surveys and expand or clarify the results of quantitative assessments. The following characteristics characterize these methods:

- They are generally open and have less structured protocols (i.e. by adding, improved or dropping techniques or informants, investigators can alter the data collected strategy);
- Interactive interviews are more important; respondents can be interviewed several times for follow-up on specific topics, clarify concepts or check the reliability of the data;
- They use triangulation to increase their findings' credibility (i.e. researchers rely on multiple methods of data gathering to check that their findings are authentically);
- Its findings are not generalizable to any particular population in general, instead each case study produces one piece of evidence to seek general patterns between different studies on the same subject.

Regardless of the kind of data involved, it takes a lot of time to collect data in a qualitative study. The investigator must thoroughly, precisely and systematically record any potential useful data using field notes, drawings, audiotapes, photos and other appropriate media. The methods of information collection must respect the ethics of research. The most common qualitative methods used in the assessment can be divided into three broad categories.

- Profound interview
- Methods for observation
- Review of the document

B. Quantitative Data:

Quantitative data are numerical in nature and can be calculated mathematically. The measurement of quantitative data uses different scales, which can be classified as nominal, ordinal, interval and ratio scales. Such data often (not always) include measurements. The 'what' in the programme are quantitative approaches? They use a systemically standardized approach and use techniques like surveys and questions. Quantitative approaches are less costly to use, standardized to enable comparisons to be carried out easily and to generally measure the effect size. However, their capacity to investigate and explain similarities and unexpected differences is limited in terms of quantitative approaches.

It is important that quantitative data collection approaches are often difficult for peer-based programmes for agencies because a lack of resources is commonly experienced, such as a lack of rigorous surveys and often low turnout and loss of monitoring rates.

The methods of quantitative data collection are based on random sampling and structured data collection instruments which fit various experiences into predetermined categories of response. They produce results that can be compared, summarized and generalized easily. The researcher uses probability sampling to determine the number of participants to be generalized from the research participants to a larger population. Typical strategies for quantitative data collection include:

- Clinical trials/experiments.
- Careful observation and recording of events (e.g., counting the number of patients waiting in emergency at specified times of the day).
- Recovery of relevant data from information management systems.

- Close-ended questions management surveys (e.g., face-to face and telephone interviews, questionnaires etc).
- Interviews are more structured than qualitative research in quantitative research (survey investigation). The researcher asks a standard set of questions in a structured interview and nothing else. Concerning face-to-face interviews, the researcher has a distinct advantage that he can relate and thus cooperate with potential participants.

Paper-pencil-questionnaires can be sent to many people and saves time and money for the researcher. People are more truthful, when answering questionnaires, in particular because their responses are anonymous, concerning controversial issues.

C. Mixed Methods:

Mixed methods are used as designs and combined in one research framework both qualitative and quantitative data, techniques and techniques. Mixed approaches may involve several aspects, namely, several different types of methods in a study or at various points within a study or using a mix of qualitative and quantitative methods. Mixed methods involve diverse approaches combining strengths and weaknesses derived from the use of a single research design. Using such a method of data collection and evaluation, validity and reliability of research can be increased. Some of the common areas for the use of mixed methods include:

Initiate, develop, develop and expand interventions;

- Evaluation;
- Enhance the design of research; and
- Corroborating results, triangulation of data or convergence.

A mixed method approach includes some of the challenges:

- Delimitation of qualitative and quantitative complementary research issues;
- Collected and analysed time-intensive data; and
- Decisions on the combining methods of research.

Mixed methods serve to highlight complex research problems, such as health disparities and can transform issues for vulnerable or marginalized populations or research involving community involvement. A mixed method approach is one way to develop creative options for research and evaluation for traditional or single design approaches. Data can be classified in many different ways. The basis for a common classification is who collected the information.

D. Primary Data:

Data collected from first-hand experience are referred to as primary data. Primary data have not yet been released and are more trustworthy, authentic and objective. Primary data have not been changed or modified by humans; its validity is therefore greater than secondary

data. Primary data import: In statistical surveys information from primary sources should be collected and primary data should be processed. The statistical records of women in a country, for example, cannot based on newspapers, magazines and other printed sources.

A research without secondary data can be carried out but a research based only on secondary data is least reliable and may be distortionary because secondary data is already manipulated by people. One source of this type is old and it also contains limited information, as well as misleading and biased information.

Sources of Primary Data: There are limited sources of primary data and sometimes data can hardly be obtained from the primary source due either to population shortages or lack of cooperation. There are some of the primary data sources below.

Experiments: Experiments need an artificial or natural environment in which logical data collection is carried out. For medicine, psychological studies, nutrition and other scientific studies, experiments are more suitable. The experimenter must monitor the influence of any alien variable on the results during experiments.

Survey: In social science, management, marketing and psychology, surveys are the most commonly used method. Surveys in various methods can be carried out.

Questionnaire: It is the most widely used survey method. Questionnaires consist of an open or closed list of questions for which the respondents provide answers. Questionnaires can be made via telephone, mail, live in public areas or in an institution, by mail or by fax.

Interview: The interview is an interview with the respondent face to face. When the questioner consciously hides information, in the interview the main issue arises, otherwise it is a thorough source of information. Not only can the interviewer record the statements that the respondent speaks, he also observes the body language, expressions and other reactions to the questions. The interviewer can therefore easily draw conclusions. Observations: An observation may be performed while informing the observer, or without informing, that he/she is observed. In the natural and artificially created environment observations can also be made.

Advantages of Using Primary Data

- The researcher collects information specific to the studied problem.
- The quality of the data collected is beyond question (for the investigator).
- Additional data can be obtained during the study period if necessary.

Disadvantages of Using Primary Data

i. All data collection has to be addressed by the investigator:

- Decide why, what and how, when to gather;
- Recovery of data (individually or through others); receipt of financing and management of funding agencies;

- Ethical aspects (consent, permissions, etc.).

ii. The collection of data is ensured to a high standard:

- All requested data is accurately collected and requested in format;
- No fake/cooked information exists;
- Not included inappropriate/unnecessary data.

iii. Data acquisition costs are often the biggest cost in study:

E. Secondary Data:

Data collected from a source published in any form is referred to as secondary information. In any research the examination of literature is based on secondary information. It is gathered for another purpose by someone else (but being utilized by the investigator for another purpose). For example, data from the census are used to analyse the impact of education on career choice and income.

Census, organisation, and data collected through qualitative methodologies and qualitative research are common sources of social science secondary data. Secondary data is important, because a new survey that captures changes and / or developments of the past cannot be carried out appropriately. Secondary data sources: Some ways to gather secondary data are as follows:

- Books
- Records
- Biographies
- Newspapers
- Censuses or other statistical data published
- Files of data
- Articles on the Internet
- Articles by other investigators (journals) Research Databases, etc.

Importance of Secondary Data:

Secondary data may be less valid, but it is still important. Primary data are sometimes difficult to obtain; in these cases it is easier and possible to get information from secondary sources. In such a situation, there are sometimes no primary data that must contain secondary data research. Sometimes primary data is available, but in such cases, the respondents are not prepared to reveal it. For instance, it is difficult to find, if you research the psychology of transsexuals first and second, they might not be willing to provide you with the information you want for your research so that you can collect information from books or other published sources. It is clear that much of the background work that is necessary to use secondary data was already done. For example, there might have been literature reviews, case studies, published texts and data elsewhere, and promotional media and personal contacts used. This abundance of background work means that secondary data

generally have an established degree of validity and reliability that the researcher who re-use such data does not have to re-examine. Secondary data may also be helpful in the research design of subsequent primary research and provide a basis for comparing the collected primary data results. Consequently, any research activity is always wise to start with a secondary data review.

Advantages of Using Secondary Data:

- No data gathering hazards.
- It's less costly.
- The researcher is not personally responsible ('I did not') for the quality of the data.

Disadvantages of Using Secondary Data:

- Third parties may not be reliable persons in collecting their data, thus reducing their reliability and accuracy.
- Data from one location may not be suitable for the environmental factor of the other due to variable factors.
- The data becomes obsolete and very old over the course of time.
- The collected secondary data may distort research findings. Special care must be taken to modify or change the use of secondary data.
- Secondary data may also raise problems with copyright and authenticity.

With the advantages and inconveniences of data sources required for the research study and time factor taken into consideration, both primary and secondary data sources were chosen.

9.2 Issues to be considered for Data Collection/ Norms in Research:

There are several reasons why adherence to ethical standards in research is important. Firstly, standards promote research objectives such as knowledge, truth and error avoidance. For instance, bans on manufacturing, falsification or misrepresentation of research data support truth and prevent error. Secondly, because research involves many different people in different disciplines, institutions and cooperation, ethical principles foster the values necessary in collaborative activities, such as trust, responsibilities, mutual respect and fairness. Ethical standards are essential. For example, many research ethical standards, such as authorship guidelines, copyright and patent policies, data sharing policies and peer review confidentiality, have been designed to defend and promote collaboration on intellectual propriety interests. Most researchers want credit for their contributions and do not want their ideas stolen or prematurely disclosed. Third, many ethical standards ensure that scientists have public responsibilities. Fourthly, ethical research standards also contribute to the development of public support for research. Individuals who rely more on the quality and integrity of research will finance their research project. Lastly, a variety of other important moral and social values, such as social responsibility, rights and animal welfare, law-enforcement and health and security, are promoted under several research standards. Ethical research deficiencies can significantly affect subjects, students and the public of humans and animals.

For instance, researchers making data in a clinical trial can damage or even kill patients and researchers who fail to comply with radiation or biological safety regulations or guidelines may compromise their health and safety or the safety and safety of staff and students.

Given the importance of Research Ethics, it is no surprise that many professional groups, government agencies and universities have adopted specific codes, regulations and policies relating to Research Ethics. This is an overview and general summary of certain ethical principles covered by different codes:

Honesty: Strive in all scientific communications for honesty. Report honest data, results, processes and publishing status honestly. Do not produce, falsify or incorrect information. Do not mislead colleagues, agencies or the public.

Objectivity: Ensure that there are no biases in experimental design, data analysis, data interpretation, peer review, personnel decisions, grants, expert reporting and other research aspects where objectivity is expected and required. Avoid or minimize prejudice or disappointment. Reveal personal or financial interests that might have an impact on research.

Integrity: Keep your promise and understanding; act sincerely; strive for coherence in thinking and acting.

Carefulness: Avoid careless errors and negligence; examine your own work and your peers' work carefully and critically. Conserving good research records such as data collection, design of research and correspondence with agencies or journals.

Openness: Share data, outcomes, ideas, resources and tools. Be open to new ideas and criticism.

Respect for Intellectual Property: Honor patents, intellectual property and other forms of rights. Do not without permission use unpublished data, methods or results. Give loans when loans are due. Provide proper recognition or credit for all research contributions. Do not always plead.

Confidentiality: Protect confidential communications, such as publication papers or grants, personal records, business or military secrets, and patient records.

Responsible Publication: Publish yourself not just to advance your own career to promote research and research. Prevent rubbish and duplicate publication.

Responsible Mentoring: Supporting student training, mentorship and advice. Promoting their well-being and making their own decisions.

Respect for Colleagues: Respect and deal fairly with your colleagues.

Social Responsibility: Endorse social wellbeing by research, public education and advocacy to prevent or mitigate social harm.

Non-Discrimination: Avoid discrimination based on sex, race, ethnicity and other factors that is not related to their scientific competence or integrity against their colleagues or students.

Competence: Maintain and improve your skills and expertise through lifelong learning; undertake measures to promote scientific expertise as a whole.

Legality: Knowing and complying with applicable legislation and institutional and public policies.

Animal Care: Demonstrate appropriate respect and care for animals in research. Do not conduct animal experiments that are unnecessary or poorly designed.

Human Subjects Protection: If you conduct research on human subjects, minimize harms and risks and maximize benefit; respect human dignity, privacy and independence; deal with vulnerable populations with special precautions; and try to fairly share the benefits and burdens of research. Research ethics training should help researchers tackle ethical dilemmas by introducing researchers to the key concepts, tools, principles and methods needed to resolve those dilemmas. The issues have indeed become so important for research training.

9.3 Methods of Primary Data Collection:

You collect the data yourself with qualitative and quantitative methods in the primary data collection. The key point here is that you and your research are the only ones who collect data and nobody else has access to them until you publish them. The primary data collection methods are numerous.
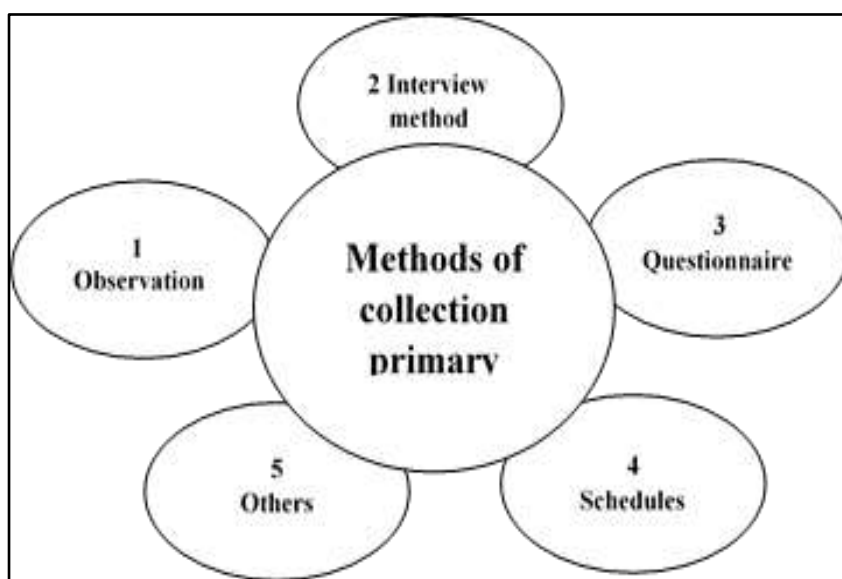

Figure 9.2: Methods of Primary Data Collection

The most important methods are:

- Questionnaires
- Interviews
- Interviews with Focus Group
- Observation
- Survey
- Case-studies
- Diaries
- Technical activity sampling
- Study of Memo Motion
- Analysis of the process
- Analysis of links
- Study of Time & Motion
- Method of experimenting
- Method of statistics, etc.

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10. Introduction to Research Process

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10.1 Introduction:

Research is a sequence of connected activities moving from a beginning to an end. Research generally starts with problem identification followed by research questions or objectives formulation. Proceeding from this the researcher determines how best to answer these inquiries and so chooses what data to collect, how to collect, and how it will be analyzed to answer the research question. Research work can be carried out for various reasons. A research study can be taken up to (i) try new research methods and techniques (ii) to satisfy the researcher's curiosity (iii) to establish the prevailing phenomena and (iv) to discover the conditions under which certain events occur. However, the point to be discussed first is identifying the sources, from where the research ideas come from.

10.2 The Process of Determining a Research Idea:

Research ideas come from everywhere. The issue with a researcher is knowing where to find them, shortlisting and narrow down the focus from the abundance of ideas that lead to investigative a research topic. A researcher working on a research idea assumes complete ownership of the research idea/problem. However, multiple researchers may be working on They can also help students develop a compelling case for their studies. similar ideas.
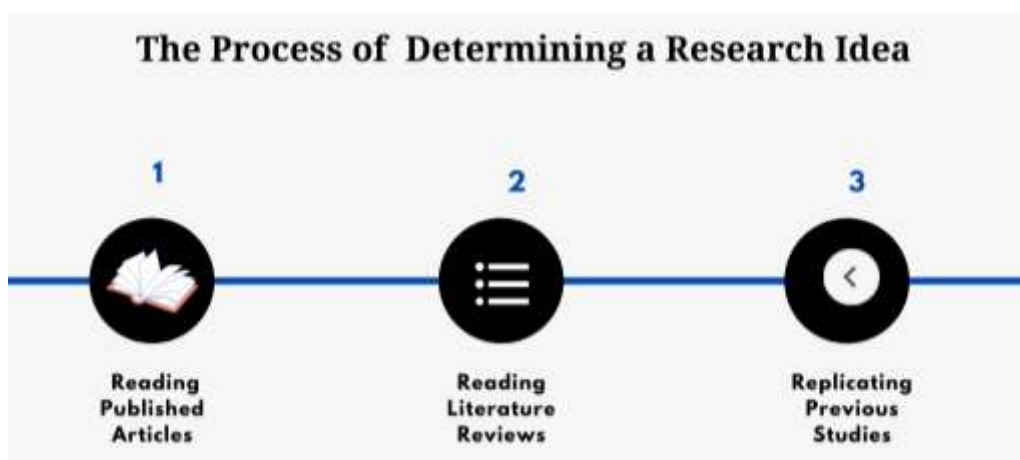
Figure 1: The Process of Determining a Research Idea

10.2.1 Reading Published Articles:

The world of investigators and their work should also be studied briefly to get a better understanding of them.

Many of the ideas that emerge from the various phases of research are generated by the people who study them.

This information gap can also be caused by different factors. For instance, it could be that the study that was reported did not focus on the specific age group of the child.

Since the article did not include children of that age, this means that the researchers did not have enough information about them to make a proper study. This means that they may want to study them in the future.

If a researcher thinks that studying children could improve a study, this may be the target of his or her next research.

There are also often gaps in the information that researchers sometimes use in their studies. In most cases, future research implications are easily identified in an article since the author typically uses terms such as "future research should" or "further investigation might be needed" or "scope for future research".

If these ideas are interesting to you, then they most likely will become your idea to work with. However, according to the literal interpretation, these ideas may not be original and are considered legitimate contributions to the field of studies.

10.2.2 Reading Literature Reviews:

Reading literature reviews (LR) can help researchers narrow down their research ideas by identifying specific areas of interest.

These reviews can also be used to identify topics that interest them.

Literature reviews are very useful sources of information on a particular topic. Some journals mainly publish reviews, while others publish articles that deal with the same topic.

These reviews can generate many research ideas that can be used in different ways.

Aside from identifying research ideas, literature reviews can also serve as educational tools for researchers. They can also help students develop compelling cases for their studies.

The structure of a published literature review article is important as the first few paragraphs introduce the reader to the topic and provide an important reason why it is important. Usually, the author will start his or her introductory statement by briefly explaining what the topic is.

This helps the reader to get a general idea of what the topic is and why it's important. The goal of an LR is to examine the results and inferences of various studies related to a broad topic.

It can also cover investigations related to specific curricular areas or topics. A researcher will review the literature on the research topic and will explain what the topic is and why it is significant to the readers, and it will conclude with a very clear statement of the research question.

The reasons for undertaking the research usually fall into one of many categories. The research might be justified because "this particular research issue has not been explored previously," and it is critical to the researcher.

Another argument may be that even though that it has been examined, prior studies had faults in their study methods" and that it is crucial for the researcher.

The third sort of explanation may be that although the issue has been researched, it has not been examined with these specific samples.

10.2.3 Replicating Previous Studies:

Replications of previous research add to the expanding body of evidence on any subject. Even if the research topic is replicated it is still very important for the researchers to conceptualize the scientific and practical logic and applicability of the topic.

A researcher may replicate the previous studies with modifications in the variables (geographic/demographic etc.), methodology, use of tools for analysis, statistical methods etc. and emerge in effective and creative ways to bring out newer insights from the research.

10.3 Research Process:

Irrespective of the category of research conducted, the process involves the same basic steps.

The basic scientific method is used to develop a hypothesis, collect data, perform analyzing experiments, and report results.

As a journey, the research process is a series of decisions that a researcher has to find the answers to the enquiries that he/she wants to answer.

Numerous steps will help a researcher to explore the answers to the enquiries. Notwithstanding the nature of research conducted, the process involves the same basic steps.

The basic scientific method is used to develop a hypothesis, collect data, perform analyzing experiments, and report results. The figure below shows the step-by-step research process:
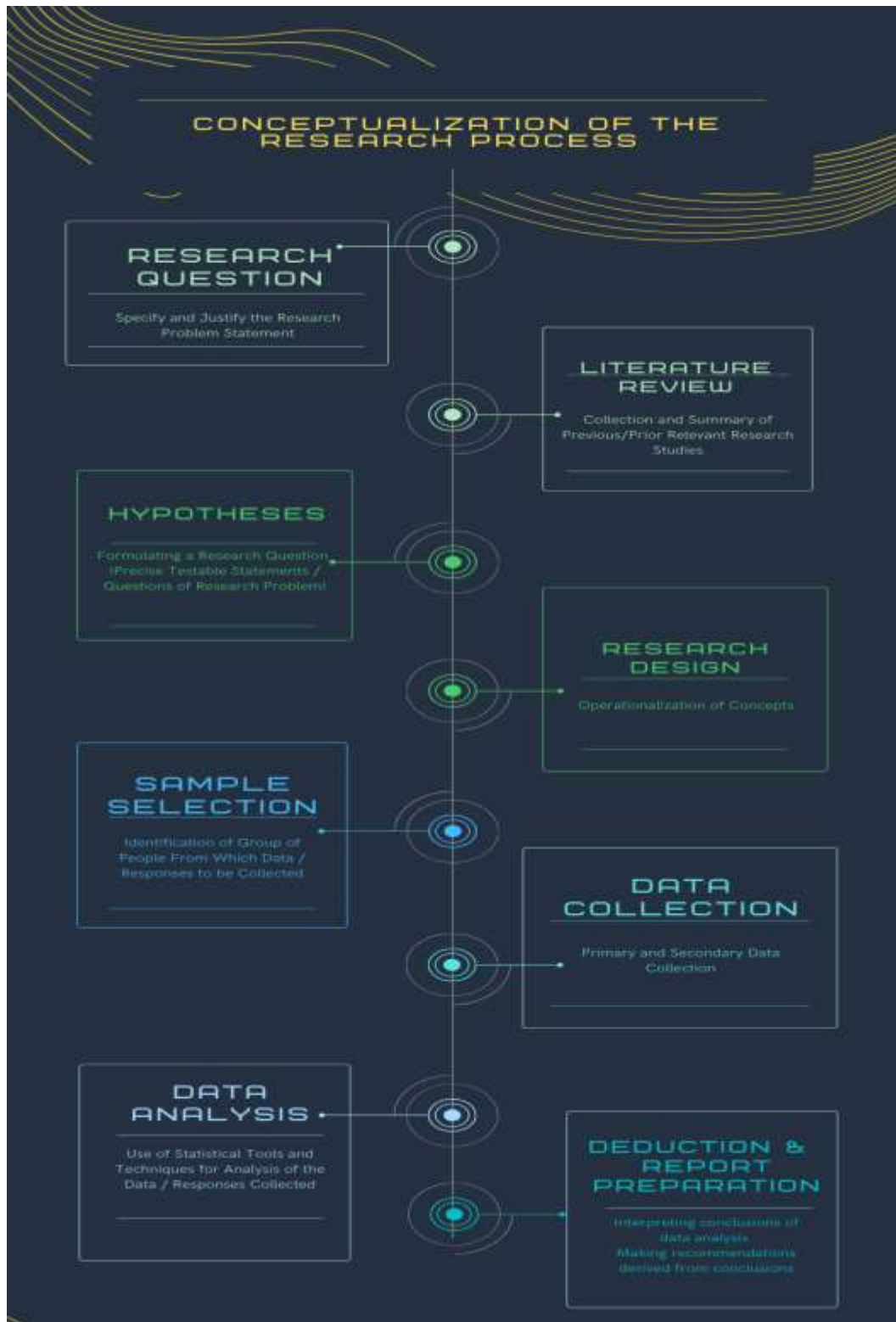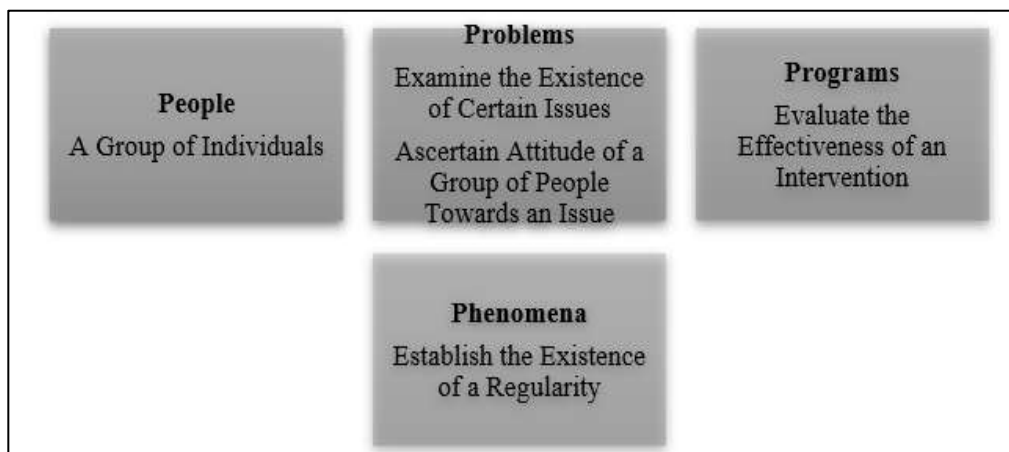
Figure 2: Research Process Steps

10.4 Step 1: Research Question

The first stage in the research process is to choose what a researcher wants to study i.e., identification of a research question.

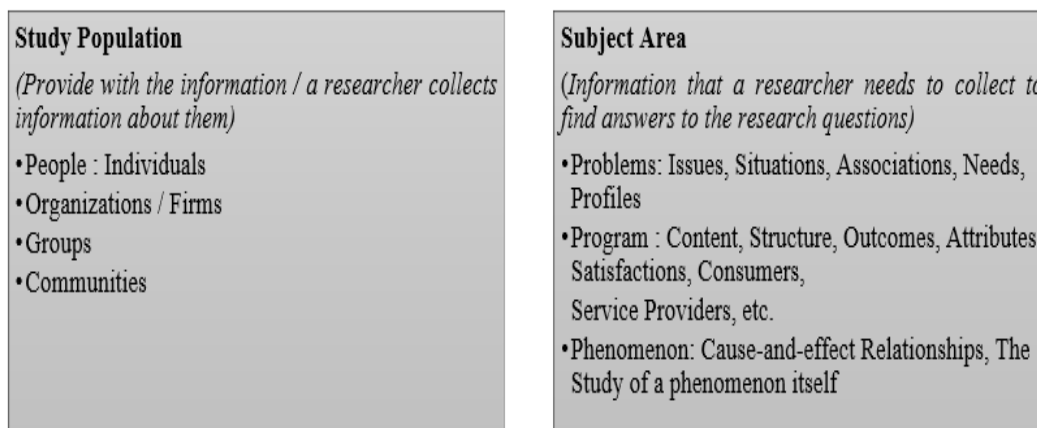This step is the most critical in the research cycle.

The various phases of the research involve identifying the sources of the problem that the study aims to address.

In social sciences, sources of research problems revolve around four **Ps:**

People
A Group of Individuals

Problems
Examine the Existence of Certain Issues

Ascertain Attitude of a Group of People Towards an Issue

Programs
Evaluate the Effectiveness of an Intervention

Phenomena
Establish the Existence of a Regularity

Figure 3: Sources of Research Problem

Maximum research works are constructed upon at least a blend of two *Ps.* Each research has dual facets:

Study Population

(Provide with the information / a researcher collects information about them)

• People : Individuals
• Organizations / Firms
• Groups
• Communities

Subject Area

(Information that a researcher needs to collect to find answers to the research questions)

• Problems: Issues, Situations, Associations, Needs, Profiles
• Program : Content, Structure, Outcomes, Attributes, Satisfactions, Consumers, Service Providers, etc.
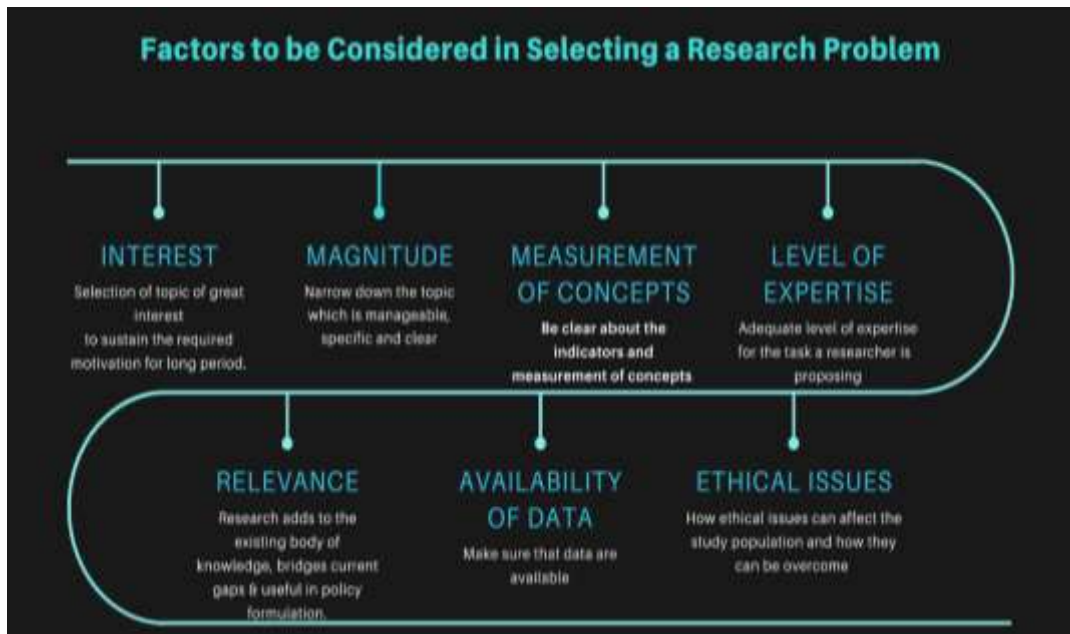• Phenomenon: Cause-and-effect Relationships, The Study of a phenomenon itself

Figure 4: Factors to be Considered for Selection of a Research Problem

10.5 Step 2: Review of Literature

One of the critical primary responsibilities of a researcher is to review the existing literature to familiarize him/herself through the existing body of knowledge in the domain of interest/research. The review of literature is an essential step of the research process and provides a valued input to nearly all the operational steps. It starts even before the first step; when the researcher is simply thinking about the research problem which he/she wants to explore/ answer through the research journey. In the early stage of research, a literature review helps a researcher to build the theoretical background of the study, clarifies ideas and helps to plan methodology. In the later stages of the research, literature review improves and combines the researcher's knowledge base and helps to assimilate the researcher's research results with the present body of knowledge which either supports or challenges the prior research. A researcher should refer to the relevant scholarly research papers of the below-mentioned categories:

Research papers reporting original research (with a classic format of introduction/background, methods, results, discussion etc.)

Reviews of others work (a systematic review to a more broad analysis of others' work).

Opinion Papers (drawing on research and other evidence).

Methodological Papers (where particular research methods or research instruments are discussed, often by presenting data to illustrate particular points).

Policy Documents (helps a researcher to think about the research idea from a wider perspective).

During this stage of research, a researcher should remember that one source/reference will lead to one more. The past researches, relevant to the research problem should be cautiously refereed. A good library (physical sources and e-resources) will be a great support to the researcher during this phase. The write-up of the literature review should be created on key topics/themes; the arrangement of the topics/themes in the review should have a rational progression; numerous opinions, validated with precise quotes and citations from the literature and should follow to a suitable academic referencing style.

10.6 Step 3: Formulating a Hypothesis

Subsequently detailed literature review, a researcher should frame working hypothesis or hypotheses. Hypotheses and research questions are the accurate statements/questions of the research problem. A hypothesis is a prediction of what is expected to occur or a relationship between the concepts of interest. A hypothesis is a premonition, supposition, doubt, proclamation or an impression about a phenomenon, association or situation. A researcher calls them hypotheses and they turn out to be the base of an investigation. The hypothesis will be built upon any earlier research studies or the researcher' or somebody else's observations.

A hypothesis is generally tested with some form of experiment. A working hypothesis is a tentative supposition made to examine its rational or experiential significance. Hypotheses also affect the type of data to be collected, and the way data are analyzed. Hypotheses should be very precise, as they direct the investigator by restricting the research domain and retain the researcher on the correct track. Developing hypotheses needs a researcher to identify one independent variable of a sampling unit that causes, effects, or influences, another dependent variable or response variable of the similar or other sampling units. In exploratory research, the base of knowledge is so limited that, a researcher cannot formulate any meaningful hypotheses.

10.7 Step 4: Research Design

The next step for the researcher is to prepare a research design i.e., he/she will be required to define the theoretical framework in which the research study will be carried out. The groundwork on the research design simplifies the process of investigation to be as effective as likely yielding utmost information.

"A research design is a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problems. The plan is the complete scheme or programme of the research. It includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data." (Kerlinger 1986: 279)

A research design has two main purposes:

i. Identification and/or development of procedures and the logistical measures essential to carry out the research
ii. To confirm their validity, objectivity and accuracy

One of the most significant necessities of a research design is to lay down everything evidently so the person who reads will comprehend the procedures and the method to follow them. A research design, consequently, should do the below-mentioned activities:

- Title the study design - that is, cross-sectional/before-and-after/comparative/control experiment/random control.
- Give comprehensive info about the subsequent facets of the research:
  o Who will form part of the study population, and in what way will the population be known?
  o Whether the research will be a sample study or a population study? Further, if the research study is based on a sample study then what will be the process to contact the respondents?
  o How will permission be asked?
  o Which process of data gathering will be used and why?
  o In the instance of a survey, where will the responses be given back?
  o Process of respondents to get connected with the researcher in case of any queries.
  o Place of conducting interviews
  o Method to take care of ethical matters

Once the research design is framed, the following step is to create/gather and select the proper tool for research. Based on the requirement of the research problem an investigator may select specific techniques such as observation, experimentation, case study, association, and survey. In case existing research tools are not available at that point the investigator might have to develop suitable tools to undertake the research.

10.8 Step 5: Sample Selection

For any research, an investigator has to carry out identification of the population of the research study which is a cluster of interest and for whom the research results will be relevant and generalized. Identification of **population** is to be defined precisely to make sure who falls within and outside it. A sample representation from the population is taken for the research purpose. **Sampling methods** are related to various methodological approaches. The random sampling method is considered the best for quantitative study design. It removes the selection bias.

Nevertheless, the sampling frame (complete list of the population) must be known for the random sampling method. While for qualitative study design purposive sampling may be used as the prospective respondents are carefully chosen for their potential to provide the most appropriate evidence for the research study based on identified characteristics. An appropriate **sampling frame** is desired and a choice is to be made if including entirely whole population who satisfy the inclusion rules or whether only a sample representative ought to be chosen. **Sample size** will depend on the resources and time available and some other conditions. Samples can be probability-based or non-probability-based. In the probability-based sampling method, every element has an equal chance of getting selected and a known probability of being included in the sample nonetheless the in non-probability-based sampling method each element does not have an equal chance of getting selected and a researcher cannot determine this probability of selection of any element.
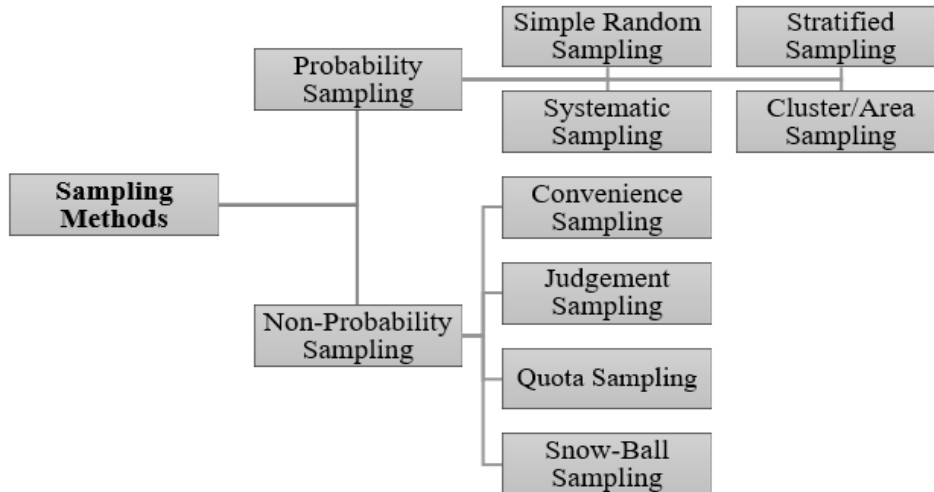
Figure 5: Sampling Techniques

10.9 Step 6: Data Collection

There are numerous ways of gathering the proper data. Primary data can be gathered either through experiments or through the survey. In the experiment, an investigator perceives quantitative measurements or the data. In a survey method, the data can be gathered in any one or more of the following ways:
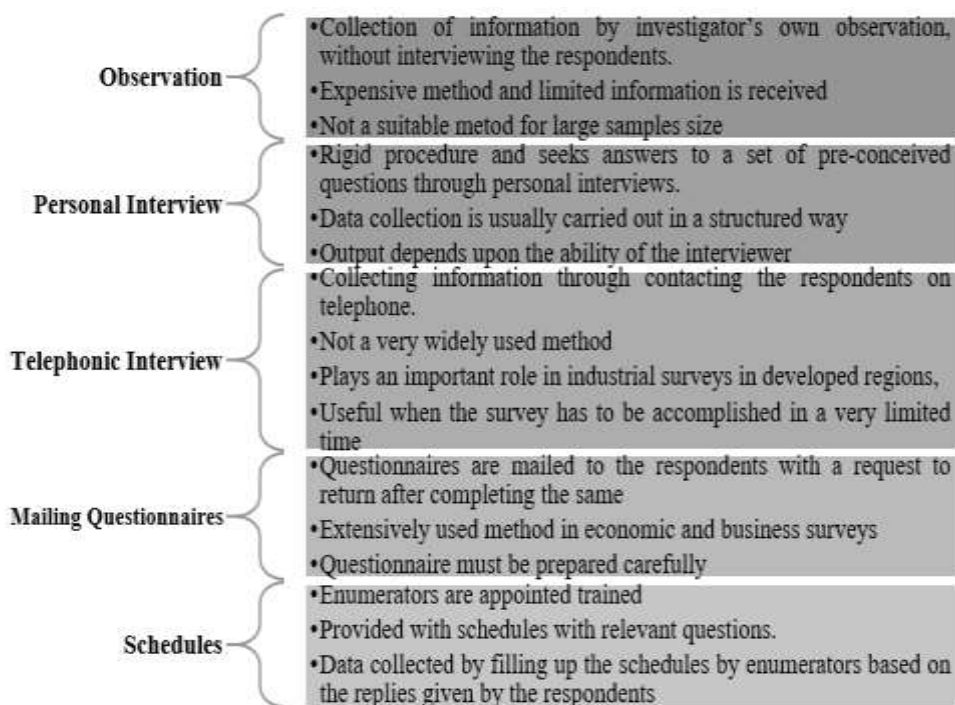

Figure 6: Data Collection Methods

10.10 Step 7: Data Analysis

The next stage after data collection is an analysis of data. This step of the research process includes the use of statistical tools and techniques to summarize and interpret relevant results. Data analysis needs a numeral of operations such as the formation of classes, converting raw data through coding, editing, tabularization then drawing statistical implications.

The data, particularly in huge studies, is tabularized by computers. Computers save time and likewise make it probable to study a huge quantity of variables that are affecting a problem instantaneously. Data analysis after tabulation is usually the calculation of percentages, coefficients, etc., through the application of various definite statistical methods.

Descriptive statistical analysis such as frequency, preparing graphs, charts, cross-tabulations, central tendency, dispersion etc. form part of quantitative data analysis. Inferential statistics are used to test the hypotheses. While in qualitative data analysis, a researcher segregates themes, finds trends, construes, describes, and even carries out theoretical evaluations.

After data analysis, the researcher can test the hypotheses (formulated earlier- step -3). Several tests, such as the Chi-square test, *t*-test, *F*-test, ANOVA etc. tests can be used by the researcher and hypotheses are confirmed through using one or more statistical tests, based on the requirement of the research inquiry. The most commonly used software is SPSS. However, currently, many licensed and open-source software are available such as R, MATLAB, Microsoft Excel, SAS, Minitab, Stata. Python etc.

10.11 Step 8: Deduction and Report Preparation

The next process is relating the evidence collected to the research question(s), drawing conclusions and inferences about the question(s) or hypotheses, acknowledging the limitations and future scope of the research. The researcher subsequently analyzing the result draws inferences. The researcher documents what the researcher has done, what was explored and what deduction the investigator has drawn from results.

This aids the reader to comprehend the research work. It permits other researchers to replicate/extend/ modify the research work. The research publications in scholarly journals or books make it accessible to all the concerns.

10.12 Summary:

This chapter included an outline of the research process, which was divided into eight steps. For a novice researcher, it is imperative to follow all the steps, though maybe not in the same order. With practice, he/she can take shortcuts. The eight steps comprise the entire range of a research endeavor, from problem formulation to writing a research report. The steps are operational, following a rational order, and specifying the numerous approaches and actions in a modest methodological manner.

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11. Protocol for Estimation of Stigma Receptivity for Solving Sustainable Breeding Approaches

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11.1 Introduction:

To understand the theoretical aspect of natural sexual reproduction mechanism and practical exploitation of different concepts of breeding for improvement in crop production, measurement of time and duration of stigma receptiveness become necessary. Any success in breeding experiments or artificial pollination produce, should be accompanied by tests on the timing and duration of the stigma receptivity (Stone et al, 1995). The gynoecium is the counterpart of reproductive system act as a female partner in a plant. A gynoecium has carpel as its functional unit comprises of three parts a terminal stigma, sub-terminal style and basal ovule. The stigma is most essential part of any gynoecium where pollen shed for fertilization. Studies on stigma receptivity includes pollination experiments like hand pollination, seed set (Ramsey and Vaughton, 1991), morphological observations like simple microscopic study or SEM and TEM study (British and Berg, 1990, Fuss and Sedgley 1991 a, b) and study of enzymes and proteins present in stigma.

The pollen-pistil interaction involves adhesion of pollen grain on stigma, pollen tube growth and entry of pollen tube into ovule, all these processes depends on stigma receptivity (Shivanna et al, 1997). One of the crucial stage in the maturation of a flower which may greatly influence the rate of self-pollination, pollination success at different stages in the flower life cycle, the relative importance of various pollinators, the interference between male and female functions, the rate of competition via improper pollen transfer, and the chances of gametophytic selection (Galen et al., 1987). Receptive stigmas are characterized by high enzymatic activity (Makwana and Akarsh, 2017). The presence of several enzymes is found to coincide with this developmental stage (Knox, 1984; Shivana and Rangaswamy, 1992) and consequently most of the methods to determine stigma receptivity *in vitro* are based on the identification of enzymatic activity (Knox et al., 1986; Dafni 1992; Kearns and Inouye, 1993). The proteins and secretary fluids present at the stigma play a crucial role in pollen germination, pollen tube growth and successful fertilization (Heslop, 1975). The receptivity of stigmas are characterized by assaying the activity of several enzymes such as peroxidase, esterase, alcohol dehydrogenase, acid phosphatase and proteins studied in different species (Shivanna and Sastri, 1981).

The methods described in this chapter is based on the previous researcher's findings for estimation or knowledge or confirmation of stigma receptivity. It can be categorized into two types:

A. Qualitative determination of stigma receptivity
B. Quantitative determination of stigma receptivity

A. Qualitative Determination of Stigma Receptivity:

There are several methods of qualitative screening which indicates receptiveness of stigma in relation to days of a thesis and flower maturation.

These methods also help in proper localization and development of pollen tube on stigma. All observations done under low and high power of simple and compound microscope.

a. In Vivo **Pollen Germination on stigma: (Joshirao and Saoji, 1989):**

Principle: Pollen grains germinate and form pollen tubes after they get deposited by the process of pollination on compatible stigma.

It emerges through one of the germ pore and passes through tissues of stigma and style to reach the ovule. The growing pollen tube is observed by staining with aniline blue.

Chemicals Required: absolute alcohol, glacial acetic acid, Sodium hydroxide, aniline blue, Disodium phosphate.

Procedure:

*   Fix a part of stigma with some portion of style with acetic alcohol (1:1) in a small vial.
*   Add few drops of 4N sodium hydroxide (NaOH) to soft stigma for 12-48 hours depending upon species.
*   Wash the soft tissue with distilled water twice to remove the traces of sodium hydroxide.
*   Stain the soft stigmas with aniline blue (water soluble aniline blue 0.05% in 0.05 M Disodium phosphate (Na_2HPO_4) on a slide, cover it with cover glass and press with thumb to make spreading of tissue into monolayer.
*   Observe the slide under low (10X) and high (40X) power of compound microscope to count number of pollen germinate on stigma.

Observation Table:

Time	Total No. of stigmas observed	Mean No. of pollen retained on stigmas	Mean No. of germinated pollen	*In vivo* pollen germination (%)	Mean pollen tube length (μm)

b. Hydrogen Peroxide test for stigma receptivity: **(Kearns and Inouye, 1993)**

Principle: The peroxidase on the surface of stigma facilitates communication between pollen and pistil by loosening the cell-wall components of the stigma which allow the entry of pollen tubes to fertilize the ovule.

This solution contains hydrogen peroxide when in contact with peroxidases present on the stigmas creates a reaction.

When it is receptive promoting the formation of air bubbles that can be easily observed by the naked eye.

Chemicals Required: Hydrogen peroxide

Procedure:

- Take about 10 stigmas of different stage of flower development to evaluate the receptivity for each stage.
- The different stages viz., before a thesis (bud stage), full bloom and withering stage.
- Keep the stigma in a cavity slide and add two drops of 4% aqueous solution of hydrogen peroxide (H_2O_2)
- Observe the slides at 20 X magnification of simple microscope for amount of bubbles formed on the stigma surface.
- Record the observations in one hour time interval from 6.00 AM to 6.00 PM.

Observation Table:

Time	Total No. of stigmas observed	Mean No. of pollen retained on stigmas	Mean No. of germinated pollen	*In vivo* pollen germination (%)	Mean pollen tube length (μm)	Production of oxygen bubbles /minute

c. Baker's procedure of Alcohol Dehydrogenase based test (Galen and Plow right, 1987):

Principle: Alcohol Dehydrogenase (ADH) is an oxido-reductase coupled with NAD (P) H (reduced nicotinamide adenine dinucleotide phosphate) which require the continuous supply of molecular oxygen as an oxidant or electron acceptor.

The number of oxygen bubbles recorded on the stigma of flowers up to 7 days after the commencement of bloom stage, which indicates the degree of receptivity of stigma.

Chemicals Required: 1M phosphate buffer, nitro blue tetrazolium, nicotinamide adenine dinucleotide, Ethanol, hydrogen peroxide (H_2O_2)

Procedure:

- First prepare the test solution consist of 10 mL of 1M phosphate buffer (pH 7.4) diluted (1 part buffer to 2 part distilled water); 6 mg NBT (nitro blue tetrazolium); 5 mg NAD (nicotinamide adenine dinucleotide) and 1 mL ethanol.
- Cut the fresh stigma and put on large droplet of prepared test solution on a slide and incubate at 8 C in closed petridish containing moist filter paper in the bottom.
- Observe the stigma after 12–18 hrs under a microscope (X10) to locate the stained area.
- Place 6% of hydrogen peroxide (H_2O_2) solution on the stigma and observe the appearance of bubbles.

Observation Table:

Sr. no.	Flower stage	Stigma colour	Stigma type	Number of bubbles

d. Stigma receptivity by Benzidine-H_2O_2 test (Dafni and Maués, 1998):

Principle: A sensitive test with a solution of benzidine, hydrogen peroxide, and sulphuric acid. The stigma receptivity is the reaction of benzidine + hydrogen peroxide, which causes receptive stigmas to change from their natural color to dark blue, besides promoting the formation of easily observed air bubbles due to the action of the peroxidases contained in the hydrogen peroxide.

However, the method relying on the reaction of α-naphthyl-acetate with fast blue B salt is considered more reliable (albeit more expensive), because the action of this solution is based on the esterase reaction, avoiding false-positive results, by changing the stigma's natural color to a darker shade or black when receptive.

Chemicals Required: benzidine, hydrogen peroxide, and sulphuric acid paper bag

Procedure:

- Isolate the Florets in transparent sulfuric acid paper bag of 1 DA (day of anthesis) to 7 DAA (days after anthesis).
- Collect the pistils at 8:00 AM and detach the stigma from it.
- Treat stigma with benzidine-H_2O_2 solution (1% benzidine: 3% H_2O_2 hydrogen peroxide: water = 4:11:22, v/v) for 10 to 15 min at 28°C.
- The pistil was regarded as receptive when more than 2/3 of the stigmatic area were stained dark blue and associated with some amount of bubbles released.

Observation Table:

Sr. no.	Flower stage	Colour of stigma	Number of bubbles

e. Localization of estarses on stigma (Shivanna and Rangaswamy (1992)**:**

Principle: Esterases are important component of the stigma-surface protein and its presence related to stigma receptivity.

Non-specific estrases present on the cuticle of stigma may involve in breakdown of cuticle barrier detecting thin layer pellicle during pollen pistil interaction. This is quite instant method of detecting receptiveness of stigma.

Chemicals Required: Solution A contains fast blue B, sucrose (10% w/v), phosphate buffer (0.15M, pH 6.8). Solution B contains α-napthyl acetate.

Procedure:

- Dip the excised stigma with style of selected stages in solution 'A' and solution 'B' separately and incubated at 25^0C in a humidity chamber for 22 min.
- After the specific period of incubation (10-20 min), remove the stigmas from solution and wash with phosphate buffer (pH 6.8).
- Mount the treated stigmas in 50% glycerine and pressed with cover slip to make uniform layer.
- Observe under microscope for development of rust colour which indicate receptiveness of stigma as well as localization of estrases on stigma.

Observation Table:

Time	No. of germinated pollen on stigma	*In vivo* pollen germination (%)	Detection of estrases (+/-)	Intensity of stigma receptivity (Esterase activity)

Precautions for Qualitative estimation of stigma receptivity:

- All stigma were checked under a magnifier (X10) for any damage on stigmatic surface.
- Wash the tissue thoroughly after fixation unless traces of fixative can bleach the colour of stain.
- Proper temperature should maintain for performing experiments.
- The days and time of anthesis should properly note down.
- The observations should make for at least 10 samples for avoiding error and confirmation.
- Intensity of oxygen bubbles or responses towards stain should mention + and – sign.

B. Quantitative determination of stigma receptivity:

The different enzymes particularly estrases, catalases and peroxidises released during pollen germination on stigma. The quantitative measurement can done through UV-VIS spectrophotometer.

The receptive stigma-surface contains extra-cellular proteins either in the form of pellicle or as a component of exudates. Stigma-surface protein play a crucial role in pollen germination, pollen tube entry into the stigma and probably incompatibility responses. The stigma also covered with exudates containing lipids, phenolic compounds, carbohydrates, proteins, phosphates, lectins and amino acids including esterases.

a. Estimation of catalase enzyme activity of stigma (Kar and Choudhuri, 1987):

Principle: The UV light absorption of hydrogen peroxide solution can easily measure between 230-250 nm. When catalase decomposes H_2O_2 , the absorption decreases with time.

Chemicals required: Tris HCl, Titanium sulphate ($TiSO_4$), sulphuric acid (H_2SO_4), distilled water

Procedure:

- **Preparation of H_2O_2 solution:** Dissolve 0.025 ml of H_2O_2 in distilled water and adjust the final volume of that solution up to 50 ml by the addition of distilled water.
- **Preparation of Ti $(SO_4)_2$:** Dilute 15% stock solution of Ti $(SO_4)_2$ up to 0.8% by the addition of 25% H_2SO_4. For making 0.8% concentration of Ti $(SO_4)_2$; Mix 3.2 ml of Ti $(SO_4)_2$ stock solution with 56.8 ml of 25% H_2SO_4.
- Crush about 20 mg stigma tissue of each sample with 5000 µl Tris HCl extraction buffer in chilled clean mortar and pastel.
- Centrifuge each mixture at 5000 rpm for 10 minutes at 4° C. Collect supernatant as protein stock store in refrigerator at 0-4° C.
- Add 0.5 ml Hydrogen peroxide (H_2O_2) with equal amount of cold crude protein stock in an eppendorf tube.
- Incubate the reaction mixture at 37°C for 5 minutes Finally, terminate the reaction by adding of 1 ml 0.8% titanium sulphate [$Ti(SO_4)_2$]
- Prepare a blank set of by adding 1 ml Ti $(SO_4)_2$ with the reaction mixture before addition of H_2O_2.
- Observe the change of colour after 5 minutes.
- Centrifuge the reaction mixtures at 5000 rpm for 10 minutes.
- Collect Supernatant of each tube and measured the absorbance at 420 nm wavelength by using UV-VIS spectrophotometer.
- Calculate the enzyme activity using the formula of Fick and Qualset (1975).

b. Estimation of peroxidise enzyme activity of stigma (Biswas and Choudhuri, 1978)

Principle: Peroxidase (POD) includes a group of specific enzymes such as NAD-peroxidase and NADP-peroxidase.

Simply known as donar: H_2O_2 oxidoreductase. POD catalyses the dehydrogenation of large number of organic compound and its activities assayed spectrophotometrically at 430 nm.

Chemicals Required: phosphate buffer, monosodium dihydrogen phosphate, disodium hydrogen phosphate, pyrogallol, distilled water

Procedure:

- **Preparation of reaction buffer:**

Prepare 0.3 mM phosphate buffer at pH 6.8 for use as reaction buffer, by mixing the following chemicals.

a. Dissolve monosodium dihydrogen phosphate (NaH_2PO_4): 2.34 g in 50 ml of distilled water.
b. Dissolve disodium hydrogen phosphate (Na_2HPO_4): 2.112 g of in 50 ml of distilled water.
c. Finally, mix 25.5 ml of NaH_2PO_4 with 24.5 ml of Na_2HPO_4 solution and the final volume of this mixture adjust up to 100 ml with the addition of distilled water.

- **Preparation of pyrogallol solution:**

Dissolve 47.25 mg pyrogallol in 25 ml of distilled water and prepare this solution fresh before use.

- **Preparation of H_2O_2 solution:**

Dissolve 0.140 ml of H_2O_2 in distilled water and the final volume of that solution adjust 50 ml by the addition of distilled water.

- Mix 0.2 ml cold protein stock with 0.2 ml of reaction buffer (0.3 mM phosphate buffer at pH – 6.8). Also add.2 ml pyrogallol and 0.2 ml H_2O_2 with that reaction mixture.
- Incubate the reaction mixtures at 25°C for 2 minutes. After 2 minutes, terminate the reaction of each tube by adding of 0.2 ml 5% H_2SO_4.
- A blank set is prepared with 5% H_2SO_4 and incubate.
- Observe change in colour and measure absorbance at 430 nm wavelength using uv-vis spectrophotometer against the blank set.
- Calculate the enzyme activity using the formula of Fick and Qualset (1975).

Calculation of Enzyme Activity:

Determine the Catalase and Peroxidase activity by calculating the difference of absorbance (ΔA) between, the activity of enzyme and 'zero time' blank set following the formula. Enzyme activity was calculated in the form of unit/minute/g.

$$\text{Enzyme activity} = \frac{\Delta A \times T_v}{T \times V \times Wt}$$

Where,

TV = Total volume of protein extract

T = Total time of incubation

v = Volume of extract used in reaction mixture

Wt = Weight of the tissue from which enzyme was extracted

Observation Table:

Time	Catalase activity (unit/min/gm)	Peroxidase activity (unit/min/gm)

c. (A) Extraction of Total protein for stigma (Singh *et al*., 1993)

Chemicals Required: Tris HCl buffer

Procedure:

- Take 20 mg stigma samples.
- Homogenizes stigmas in 1500µl of 0.2 M Tris HCl buffer, pH 7.4 at 4°C.
- After that centrifuge at 10,000 rpm for 10 min. at 4°C.
- Collect the supernatant and store the stigma protein at -20°C for further analysis.
- Estimate the protein concentration by Bradford (1976) assay.

d. (B) Estimation of Total protein for stigma (Bradford, 1976)

Principle: The assay is based on the ability of proteins to bind with coomassie brilliant blue G 250 and form a complex whose extinction coefficient is much greater than that of dye.

Chemicals Required: BSA, Bradford reagent

Procedure:

- To prepare a blank set mix 1 ml Bradford reagent with 1 ml double distilled water.
- Add 10 µl of protein solution (previously extracted protein) with 990µl of double distilled water in a test tube.
- Add 1 ml of Bradford reagent to each test tube.
- Vortexed gently and incubated at 25°C for 10 minutes.
- The colour of the solutions on each tube turned blue.
- The absorbance was taken at 595 nm wavelength.
- Estimate amount of protein of each sample using the standard curve of Bovine Serum Albumin (BSA).
  Prepare 1 mg/ml Bovine Serum Albumin (BSA) stock as standard BSA solution and prepare standard curve using 0.01 ml, 0.02 ml, 0.04 ml, 0.06 ml, 0.08 ml and 1 ml of BSA stock solution against their respective optical density (OD) values at 595 nm.

The amount of total soluble protein present within the test plant samples can estimate

using the equation:
$$\frac{Concentration\,of\,known\,proteins\,ample\,of\,BSA}{OD\,value\,at\,595\,nm\,of\,known\,proteins\,ample\,of\,BSA} = \frac{Concentration\,of\,unknown\,protein\,of\,pollen}{OD\,value\,at\,595\,nm\,of\,unknown\,protein\,of\,pollen}$$

- From standard curve, concentration of known protein sample of BSA and O.D. value of BSA samples obtain and estimate amount of total soluble protein present in the stigma from the above equation.

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List of Chapters