**Scientific Writing and Research Methodology** **PSPHY PR1, (M. Sc. Physics 4th Sem)**

 Credits 4 LTPS (3106)

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**Module 2**: Types of research, exploratory, conclusive, modelling and alogrithmic. Research process: Identification of research problems, selection of a problem, formulation of a problem. Data collection: data analysis, interpretation of results, validation of results.

**Types of Research**

Generally, research comprises of defining and redefining problems, formulating hypothesis or suggested solutions; collecting, organizing and evaluating data; making deductions and reaching conclusions; and at last carefully testing the conclusions to determine whether they fit the formulating hypothesis.

Exploratory research or formulative research: The objective of exploratory research is to gather preliminary information that will help define problems and suggest hypotheses. It is used to ensure additional research is taken into consideration during an experiment as well as determining research priorities, collecting data and honing in on certain subjects which may be difficult to take note of without exploratory research.

Conclusive research: Research can also be classified as conclusion-oriented and decision-oriented. Decision-oriented research is always for the need of a decision maker and the researcher in this case is not free to get on research according to one’s own preference.

Conclusive research is meant to provide information that is useful in reaching conclusions or decision-making. It tends to be quantitative in nature, that is to say in the form of numbers that can be quantified and summarized. It relies on both secondary data, particularly existing databases that are reanalyzed to shed light on a different problem than the original one for which they were constituted, and primary research or data specifically gathered for the current study. The purpose of conclusive research is to provide a reliable or representative picture of the population through the use of a valid   research instrument. In the case of formal research, it will also test hypothesis.

Modelling and algorithm: In research, model is a pictorial or graphic representation of key concepts. It shows the relationship between various types of variables e.g. independent, dependent, moderating, mediating variables etc. Models are developed and used to help scientists, engineers, decision makers to understand and communicate about a system of interest with the ultimate aim of bringing a positive change to how a system is built and/or managed. Models are a simplified representation of the modelled system. To be useful, models need to provide a cognitively-mediated environment to explain the systemic behaviour. If a model keeps growing in complexity, it will be difficult to understand and use. Yet, in many applications, large models are inevitable to support system understanding, and decision making at the appropriate and acceptable level of detail. This has been long recognized as the 'modelling paradox'. Second, models are limited to the collective cognitive complexity of the "mental models" of those involved in model development. Our mental models are however a flawed, incomplete, and sometimes inconsistent, representation especially of dynamic and complex systems. However, they give a good lead about the real system. In Physics we have so many models like plum pudding model of atom, Rutherford’s model, Bohr’s model, liquid drop model of nucleus, nuclear shell model and standard model of particle Physics et al. Some of them were outright rejected while other were improved and still being improved with various degrees of sophistication.

**Research Process**

1) Identification of research problem

2) Broad literature survey

3) Hypothesis formulation

4) Preparation of research design

5) Data collection

6) Data Analysis

7) Generalizations and interpretation

8) Hypothesis testing /validation of result

9) Preparation of the report (dissertation or thesis) and presentation of the results

**Identification of research problems**

The selection of a good research topic is central to the entire research-write process. Make sure your topic of scientific investigation is one that self-recommends itself. Your research topic must be current, with clear and logical connections to previous knowledge and must add valuable new insights to the field of enquiry. In order to select a topic worthy of investigation make sure that you keep abreast of developments in your field by reading journals, magazines and trade publications, as well as following relevant institutional and organizational websites. Discussions with research advisors are also extremely beneficial. It is always a good idea to get some feedback from advisors as to the worth of pursuing a certain line of enquiry. When you are certain that a good research topic has been identified then you can proceed with planning how to carry out the research itself.

**Broad literature survey:**

The researcher should undertake vast literature survey concerned with the problem. For this purpose, the abstracting and indexing journals and published or unpublished bibliographies are the first place where researcher can get the information or knowledge. Academic journals, conference proceedings, government reports, books etc., must be hit depending on the nature of the problem. After this the researcher revise the problem into analytical or operational terms i.e., to put the problem in as specific terms as possible. Once the problem is formulated, a synopsis of it should be written down.

**Hypotheses formulation**:

After the literature survey, researcher should make a hypothesis or working hypothesis. Working hypothesis is a guess made to test the logical or empirical outcome of a research. A hypothesis assists to explain the research problem and objective into a comprehensive explanation or prediction of the expected results of the study.

**Preparation of research design:**

Research design refers to general procedure that you choose to combine the various components of the study in a consistent and logical way. It comprises the outline for the collection, measurement, and analysis of data. There are several research designs, such as, Descriptive (e.g., case-study, naturalistic observation, survey), Correlational (e.g., case-control study, observational study), Semi-experimental (e.g., field experiment, quasi-experiment), Experimental (experiment with random assignment), Review (literature review, systematic review) and Meta-analytic.

**Data Collection**:

Data may be collected by actual observations, experiments, Questionnaire based survey, modelling, simulation, computation and programming etc. Sometimes some primary data available in literature can also be used for further use and manipulation. When collecting data for a physics experiment, there are a couple of things to keep in mind: measurement technique, trials, and experimental uncertainty. Your measurement technique is important because it affects the quality of your data. It's also important to do multiple trials, which means repeating your experiment several times. The more trials you do, the better your average value will be. Last of all, you need to always consider the uncertainty involved in any measurement. Some of this uncertainty comes from the instruments, which we call measurement error. But there is also human uncertainty, which we call random error.

**Data Analysis**

Data may be analysed by developing correlations. Graphics and statistical tools often help in analysing the data and reaching to some conclusion. In physics, the first and most important graph we create is a scatter plot showing how the two variables relate to each other. We generally put the dependent variable on the y-axis of the graph and the independent variable on the x-axis. The data is plotted as points, then a line of best fit is plotted through the data. This curve best represents the data shown, one that goes as close as possible to all of the data points. From this curve a correlation between the independent and dependent variables is developed.

**Conclusion and validation**

The conclusion drawn by analysis is finally compared with the original hypothesis to check whether it validates it or not. After all these steps, the research is reported in the form of a thesis. It is then examined by independent researcher/examiner. The students are then required to defend their thesis in front of a panel of examiners. It must be realized that a master’s or doctoral thesis is a training for a student to learn to carry out a project independently.

**Sources**

Wikipedia

https://www.springer.com/gp/authors-editors/authorandreviewertutorials/writing-a-journalmanuscript/identifying-you-research-question/10285494