# How to Conduct a Scientific Research

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# Biography

Mohd Abdur Rashid received Ph.D. in Electrical and Information Engineering from University of the Ryukyus, Japan. He is a Professor in EEE Department at NSTU Bangladesh, and currently working as Visiting Professor at Gunma University, Japan. He also worked as a faculty member in Malaysia for six years, and as Post-Doctoral Fellow for three years in Japan and Canada. He has authored more than 96 technical papers in journals and conferences. His research interests are multidisciplinary fields including mathematical modeling, electronic devices and biomedical engineering.

# Lecture Outline

- How to Start a Research?
- Types of Research
- Steps of Scientific Research
- Selection of Research Area and Topic
- Research Question
- Details of Literature Review
- Research Hypothesis, Goal & Objectives
- A part of my PhD work as an example
- Suggestions for graduate students
- Success story to publish research work

# To Know How to Start a Research?

You need to Know :

- why you are doing research ?
- what research can do ?

# Why you are doing research?

Research helps us to:

Discover new knowledge

Seek answer to questions

Enhance knowledge

# 1. Why Do Research ?

- Research teaches methods of discovery?

  And allow you to discover !

- ✓ It asks you to discover what you know on a topic. Beyond reading, it often expects you to venture into the field for interviews, observation, and experimentation.

- ✓ You may not arrive at any final answers or solutions, but you will come to understand the different views on a subject.

# 2. Why Do Research ?

- Research teaches investigative skills:

✓ A research project requires you to investigate a subject, gain a grasp of its essentials, and disclose your findings. The exercise teaches important methods for gaining knowledge on a complex topic.

✓ Your success will depend on your negotiating the various sources of information, such as reference books in the library, computer databases, and the most recent articles.

# 3. Why Do Research ?

- Research teaches critical thinking:

✓ As you go through your subject, you will learn to discriminate between useful information and unfounded information.

✓ Some sources, such as internet will provide you reliable material but may also give you worthless opinions.

# 4. Why Do Research ?

- Research teaches logic:

✓ For example: like a judge in the courtroom, you must make perceptive judgment about the issues surrounding a specific topic.

✓ Your decisions, in effect, will be based on the wisdom gained from research of the subject. Your paper readers will rely on your logical response to your observation, interviews, and testing.

# 5. Why Do Research ?

- Research teaches basic ingredients of argument:

✓ In most cases, a research paper requires you to make a claim and support it with reasons and evidence.

✓ For example, if you argue that “urban sprawl has invited wiled animals into our school backyards” then you have to defend your assertion with evidence.

# Types of Research

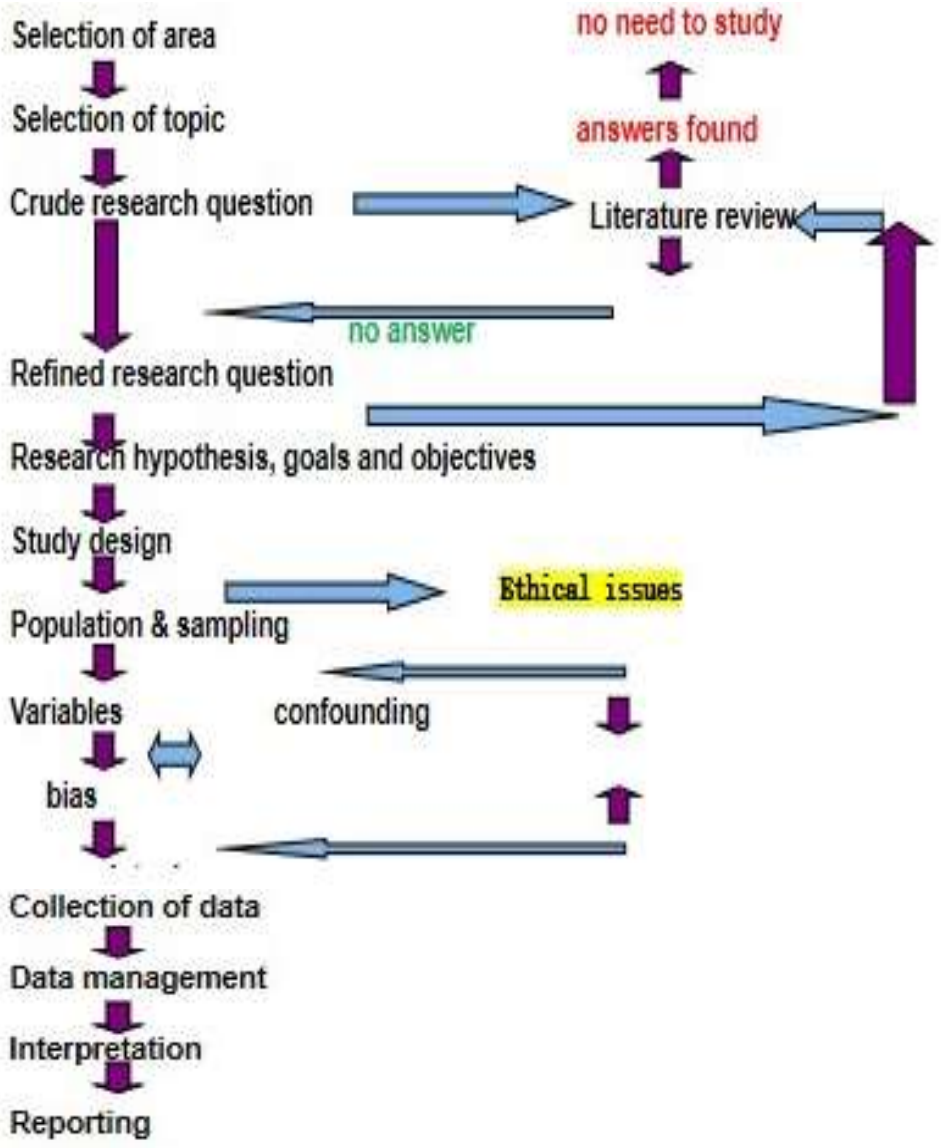
- Basic research
  - Driven by fundamental/general knowledge
  - High impact, example: theory of relativity
- Applied research
  - Driven by practical needs.
  - High impact, example: computers

**Others must learn something new from your work that can't be learnt from any existing literature.**

# **Types of Research** (Cont.)

| Research | Methods | Strengths | Drawbacks |
|---|---|---|---|
| **Descriptive Research** | Snapshot of thoughts, feelings or behaviors | Allow capturing the complexities of everyday behavior.<br>Provides detailed picture of what is occurred at a given time. | Cannot answer how a certain behavior develops, what impact the behavior has, and why the behaviors was performed. |
| **Co relational Research** | Systematic Relationships among variables<br>**Pearson's correlation coefficient** | Allow testing of expected relationships among variables and making of predictions. | Cannot identify causal relationships among variables.<br>Remains a possibility that other variables caused observed variable to be correlated. |
| **Experimental Research** | Causal relationships of more than two variables | Allow drawing of conclusion about the causal relationships among variables. | Cannot experimentally manipulate many important Variables. |

# Steps of Scientific Research



# Selection of Research Area

- Researcher's:
  - Specialty
  - Interest
  - Scientific background
  - Experience
- Actual need for research in this area
- Available resources

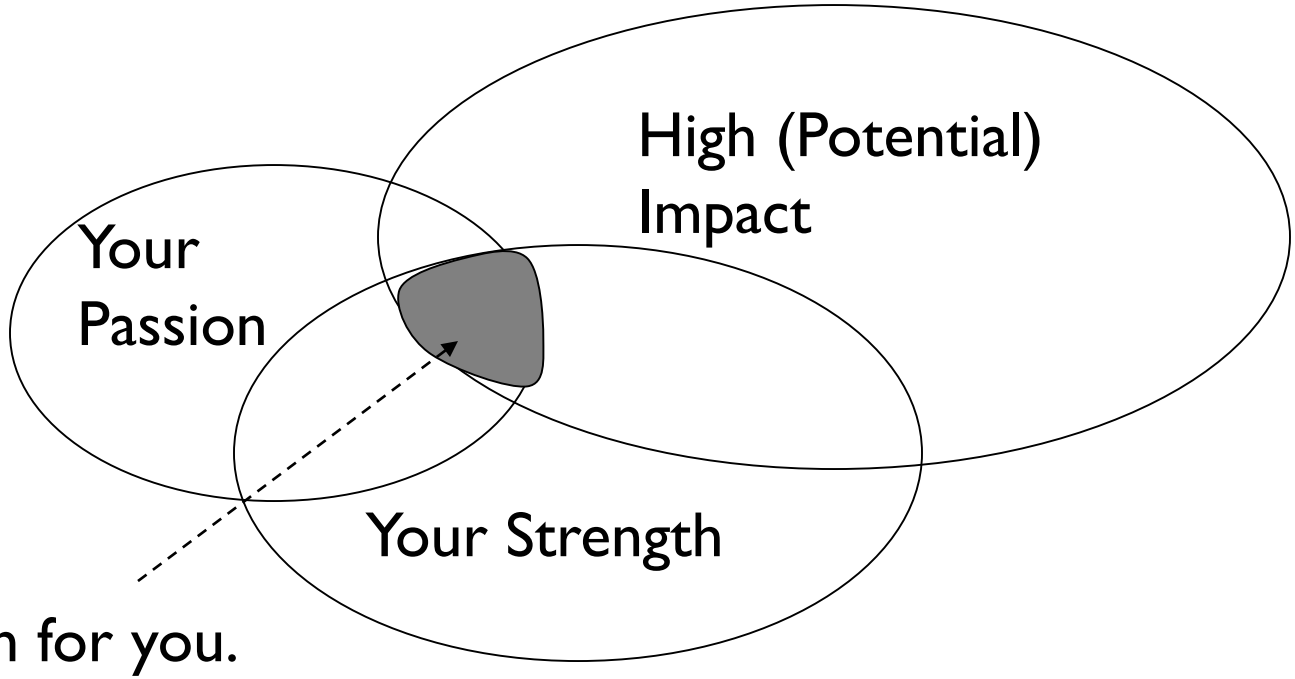
# Selection of Research Topic

The priority of research topic depends on:

- The characteristics of the problem:
  - Magnitude
  - Seriousness
  - Available alternatives
  - Proposed solutions

- The characteristics of the proposed study:
  - Feasibility
  - Cost-effectiveness
  - Applicability of the results
  - Social and Environmental impact

# Optimizing "Research Return": Pick a Problem Best for You



# Research Question

**The investigator must make sure that:**

- He has a **research question.**
- The question is **clear** and **specific.**
- It **reflects the objectives** of the study.
- It has no answer in the **Literature.**
- Finding an answer to the question **will solve or at least help in solving the problem to be investigated**.

# What is “Literature Review”?

Survey scientific articles, books, journals, dissertations and other sources […] relevant to a particular issue, area of research, or theory, providing a description, summary, and critical evaluation of each work.

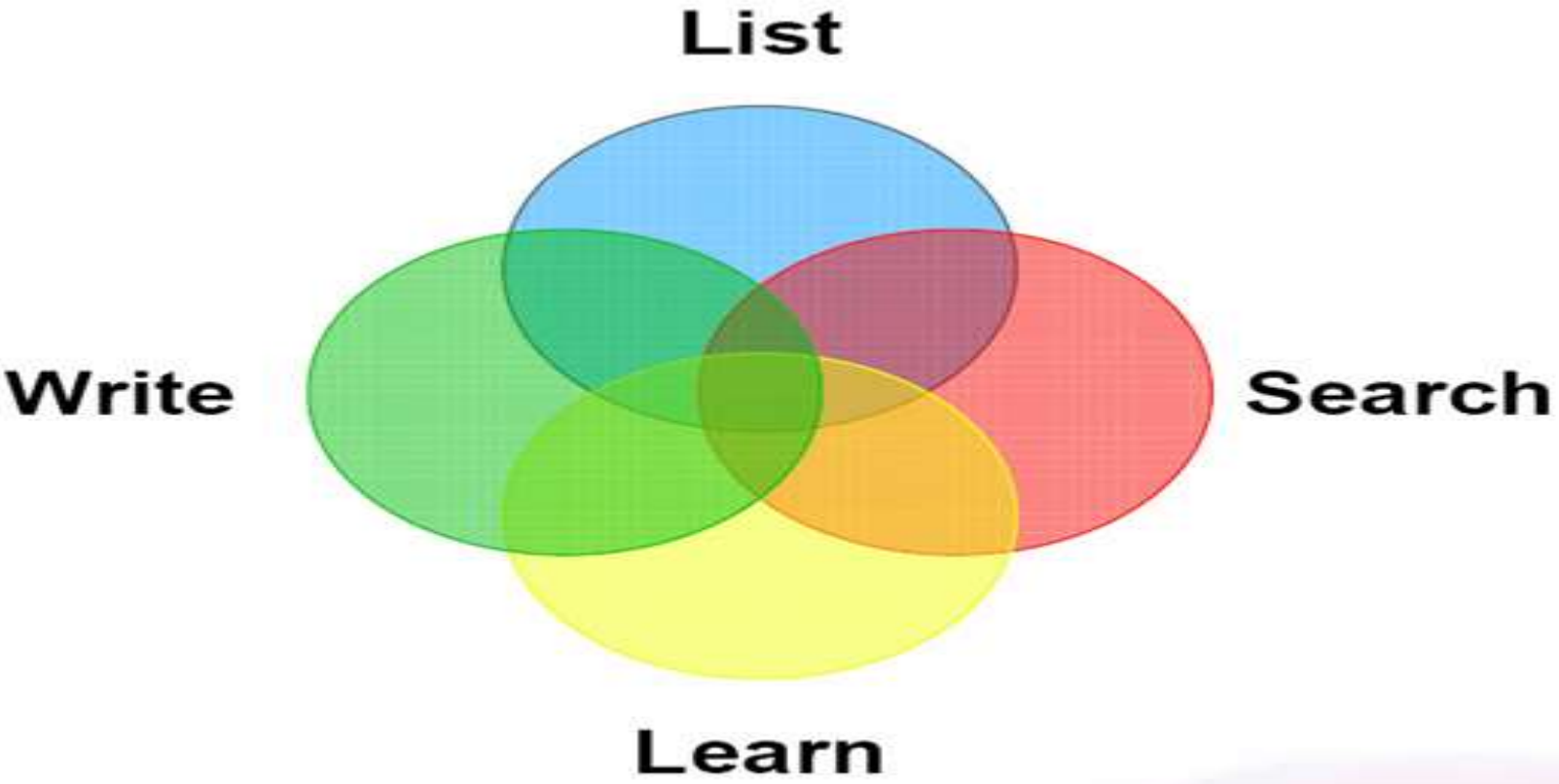
# Literature Review

# Purpose of Literature Review

A literature review may constitute an essential chapter of a thesis or dissertation. In either case, **its purpose is to:**

- Describe the relationship of each work to others under consideration.
- Resolve conflicts amongst contradictory previous studies.
- Identify areas of prior research to prevent duplication of effort.

# Literature Review as a Process



# Components of Literature Review

- **Problem formulation**:—which topic or field is being examined and what are its component issues ?
- **Literature search—**finding materials relevant to the subject being explored.
- **Data evaluation—**determining which literature makes a significant contribution to the understanding of the topic.
- **Analysis and interpretation—**discuss the findings and conclusions of pertinent literature.

# Sources of Literature

**Journal articles**:

- best sources
- concise up-to-date information.
- refereed materials.

**What about Non-refereed Journals?**

**Trade Journals / magazines** use less rigorous standards of screening prior to publication.

Non-refereed materials are not checked as intensely as refereed materials. **Not good sources of literature and research.**

# Sources of Literature (cont.)

**Books**:

- Remember, books tend to be less up-to-date, as it takes longer time to get published than for a journal article.

- They are still likely to be useful for including in your literature review as they offer a good starting point from which we can get more detailed and up-to-date information.

# Sources of Literature (cont.)

**Conference proceedings**:

- Useful in providing the latest research, or research that has not been published.
- Helpful in getting information about people in different research areas.
- Helpful in tracking down other works by the same researchers.

# Sources of Literature (cont.)

**Government/corporate reports**:

- Many government departments and corporations carry out research works.

- Their published reports can be very useful sources of information, depending on your field of study.

# Sources of Literature (cont.)

## Thesis / Dissertations:

- These can be very useful sources of information. However, there are some disadvantages.

➢ difficult to obtain since they are not published.

➢ Available only from the library or inter-library systems.

- Student who carried out the research may not be an experienced researcher. Therefore you have to consider their findings with more caution than published research.

# Sources of Literature (cont.)

**Internet**:

- Internet is the fastest-growing source of information.
- bear in mind that anyone can post information on the Internet so the quality may not be reliable.
- the information you find may be intended for a general audience and so not be suitable for inclusion in your literature review (information for a general audience is usually less detailed).

# Additional Resources

- http://scholar.google.com/
- http://ieeexplore.ieee.org/Xplore/
- http://www.scopus.com/home.url
- http://www.ncbi.nlm.nih.gov/pubmed

# Additional Resources (cont.)

- http://highwire.stanford.edu/lists/freeart.dtl
- http://www.jstor.org/
- http://www.ojose.com/
- http://www.springer.com/



# Additional Resources (cont.)

- http://pubs.acs.org/page/publish-research/episode-1.html
- http://www.lib4ri.ch/files/2014_07_oa_journals_scie.xls
- http://doaj.org/
- www.dovepress.com
- http://www.elsevier.com/ data/assets/pdf_file/0005/116447/how-to-write-a-world-class-paper.pdf
- http://taiwan.elsevier.com/htmlmailings/AuthorWorkshop-_SP-PPT-Sep%2009.pdf
- http://www.utsa.edu/lrsg/Teaching/GEO6011/HowToWriteP_aper.pdf
- http://lib.semi.ac.cn/tshg/pxjs/How%20to%20Write%20a%20World%20Class%20Paper%20(THEORETICAL).pdf

# When you are on track,
# Search again on your chosen field !!!

# Assessment of a paper

In assessing paper, consideration should be given to:

- **Origin—**What are the author's credentials? Are the author's arguments supported by evidence (e.g. primary historical material, case studies, narratives, statistics, recent scientific findings)?
- **Significance—** is the author’s work convincing?
- **Value—**Does the work  contribute in any significant way to an understanding of the subject of my research?

# Information Collection from a Paper

Information should be collected from the following four components:

- The introduction
- The body
- Result & Discussion
- The conclusion

# Information from Introduction

In introduction, you should:

- identify the general topic, area of concern, thus providing an appropriate context for reviewing the literature.
- Point out overall trends in what has been published about the topic; or conflicts in theory, methodology, evidence, and gaps in research.
- Establish the writer's reason (point of view) for reviewing the literature; explain the criteria to be used in analyzing and comparing literature.

# Information from Body

In the body, you will find:

- Group research studies and other types of literature (reviews, theoretical articles, case studies, etc.)
- such as qualitative versus quantitative approaches,
- conclusions of authors,
- specific purpose or objective, etc.

# Information from Result

- Finding of individual studies
- Comparisons with other studies
- Analyses of the findings.
- Positive side of the paper
- Significance of the paper

# Information from Conclusion

**In the conclusion, you will find:**

- Major contributions of studies and articles to the body of knowledge under review, maintaining the focus established in the introduction.

- Major methodological flaws or gaps in research, inconsistencies in theory and findings
- Scope of the future study.

# A few things those worked for me…

- Use effective search strategies.
- Collect reliable journal (IEEE, IET preferred)
- Point out **everything** you read.
- Write summary with **positive** and **negative** findings.
- Formulate research gaps from **negative** findings.

# A few things those worked for me…(cont.)

- Find out which you **believe** that you can solve.
- Fix your **Problem statement.**
- Ask questions !

# Research Hypothesis

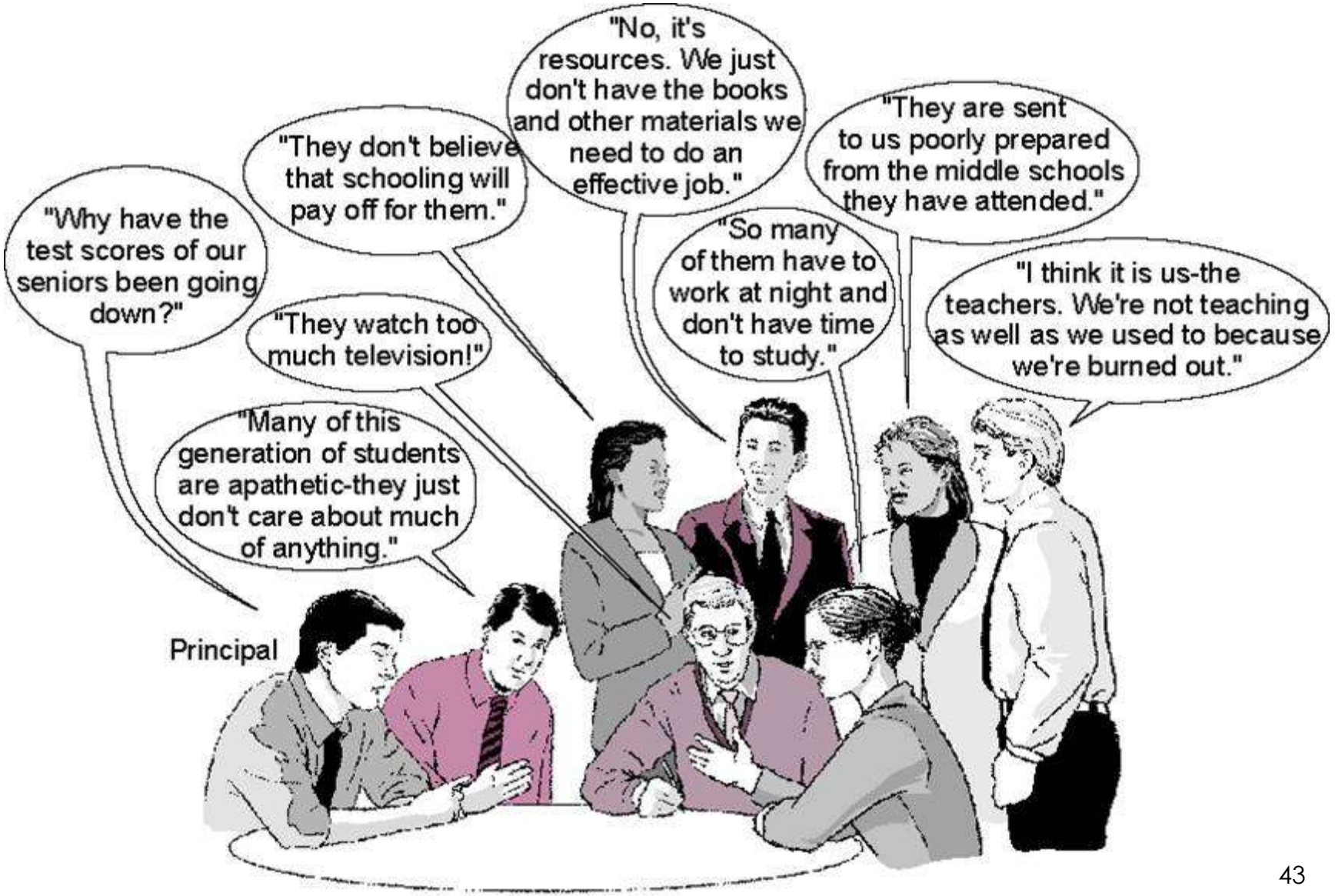
- " Research hypothesis is a statement of the research question in a measurable form"

  - Null hypothesis
  - Alternative hypothesis

# Research Hypothesis (cont.)

- A hypothesis can be defined as the prediction of the relationship between one or more independent variables and one dependent variable.
- A hypothesis translates the problem statement into a precise, clear prediction of expected outcomes.
- It must be emphasized that hypotheses are not meant to be haphazard guesses, but should reflect the depth of knowledge, imagination and experience of the investigator.

# Hypothesis from a Research Question



# Directional vs. Non-directional Hypothesis

A directional hypothesis is one in which the researcher indicates the specific direction that he expects in the study.

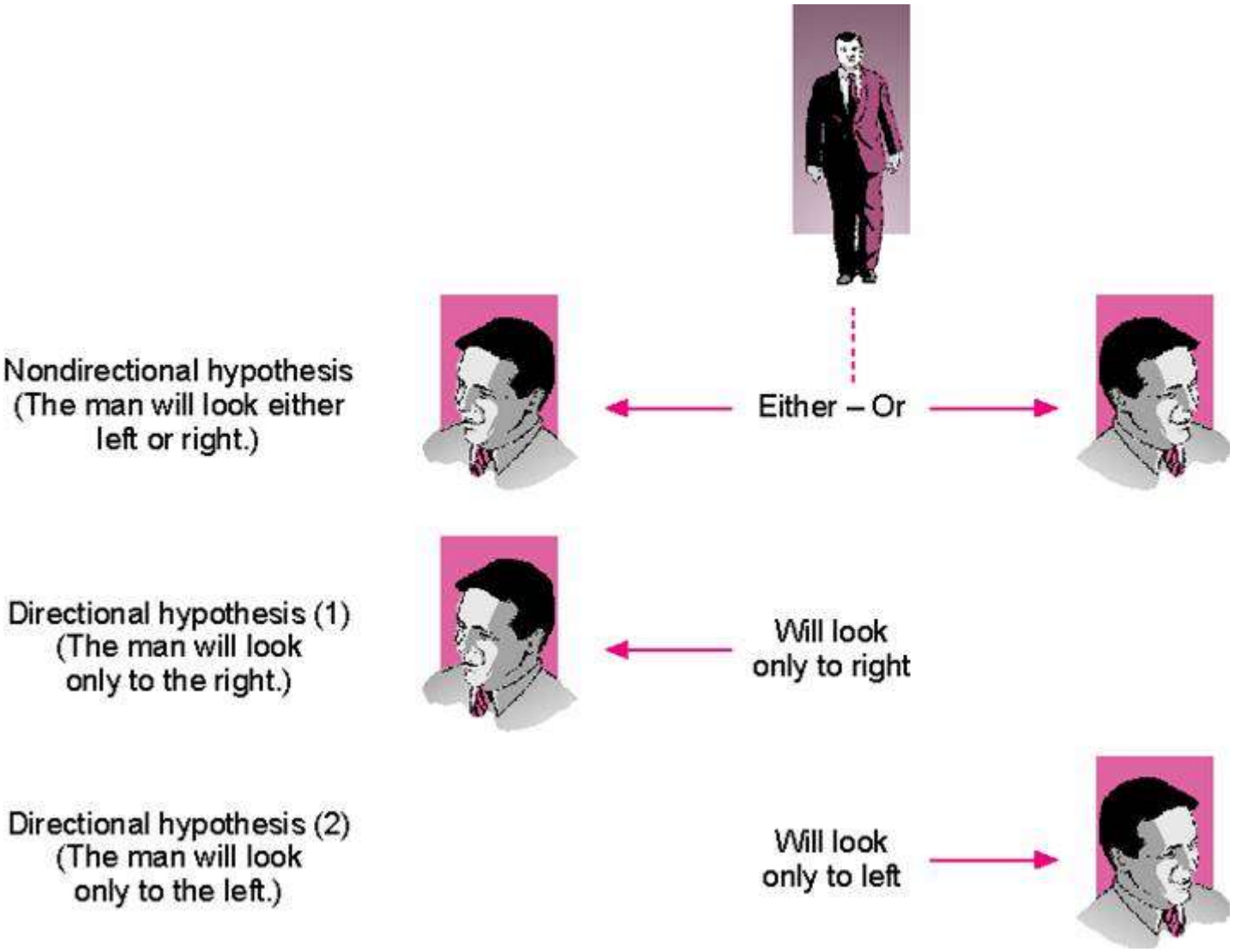
The direction is based on what the researcher has found from:

- Literature
- Personal experiences
- Experience from others

A non-directional hypothesis is when there is no specific prediction about what direction the outcome of a study will take.

- Sometimes it is difficult to make specific predictions on the study.
- A study may state that it would point to non-specific directions vs. distinct possibilities

# Directional vs. Non-Directional Hypothesis



# Research Goals and Objectives

**Goals** $\neq$ **Objectives**

# Research Goal and Objectives

- The goal (aim) and objectives must be stated at the very beginning of the study, since they will guide the investigator during the process of formulating research questions and hypothesis.

- They will enable the reader to judge whether the investigator had achieved these objectives or not.

# Research Goals

- It describes the aim of work in broad terms.

# Research Objectives

These are more specific and relate directly to research question. These are divided into two types:

- Primary objectives → (must be achieved)
- Secondary objectives → (may by achieved)

# Research Objectives

The research objectives should be:

- Closely related to the research question
- Very specific
- Stated in action verbs e.g. to describe, to identify, to measure, to compare, etc.
- Achievable, taking into consideration the available resources and time
- Mutually exclusive, with no repetitions or overlaps

# **SMART** Objectives

- S → Specific
- M → Measurable
- A → Achievable
- R → Relevant
- T → Time-bound

# Specific Example of Goal and Objective:

- **Area:** Solid State Device Design
- **Topic:** Performance Improvement of Quantum Dot Based Laser Using InN
- **Goal:** to improve overall performance of laser
- **Objective:**
  - To reduce the internal losses of laser
  - To enhance the gain/amplification
  - To improve the efficiency

# Example: A part of my PhD Research

- **Area:** Numerical computation of mathematical functions
- **Topic:** Cylindrical functions
- **Goal:** to overcome the limitation of Watson's method
- **Objective:**
  - To develop a new method for calculating cylindrical function of complex order with arbitrary values of m.
  - To improve the efficiency.

# Set research question

Watson's Series give high precise vale of cylindrical function?

Answer: No

**Watson's Asymptotic Series for $\nu \doteqdot \pm x$**

$$J_\nu(x) \sim \frac{1}{3\pi} \sum_{m=0}^{\infty} B_m(\epsilon x) \sin\{(m+1)\pi/3\} \frac{\Gamma\{(m+1)/3\}}{(x/6)^{(m+1)/3}}, \qquad (2.1a)$$

$$N_\nu(x) \sim -\frac{2}{3\pi} \sum_{m=0}^{\infty} (-1)^m B_m(\epsilon x) \sin^2\{(m+1)\pi/3\} \frac{\Gamma\{(m+1)/3\}}{(x/6)^{(m+1)/3}}, \qquad (2.1b)$$

$$\epsilon x = x - \nu\,.$$

$$B_0(\epsilon x)=1\,,\quad B_1(\epsilon x)=\epsilon x\,,\quad B_2(\epsilon x)=\frac{\epsilon^2 x^2}{2}-\frac{1}{20}\,,\quad B_3(\epsilon x)=\frac{\epsilon^3 x^3}{6}-\frac{\epsilon x}{15}\,,$$

$$B_4(\epsilon x)=\frac{\epsilon^4 x^4}{24}-\frac{\epsilon^2 x^2}{24}+\frac{1}{280}\,,\quad B_5(\epsilon x)=\frac{\epsilon^5 x^5}{120}-\frac{\epsilon^3 x^3}{60}+\frac{43\epsilon x}{8400}\,.$$

**These series can not give satisfactory precision, because $B_m(\epsilon x)$ unknown when $m \geq 6$.**

## New Method of Calculating $B_m(\epsilon x)$

The coefficient $b_m$ is defined as

$$b_m = \frac{1}{6\pi i} \int^{(0+)} \frac{\exp(\epsilon x w) dw}{(w - \sinh w)^{(m+1)/3}} \,. \tag{2.2}$$

Conversely, the relation between $b_m$ and $B_m(\epsilon x)$ is given by

$$b_m = \frac{\exp\{(m+1)\pi i/3\}\, 6^{(m+1)/3} B_m(\epsilon x)}{3} \,. \tag{2.3}$$

Using Eqs. (2.2) and (2.3),

$$B_m(\epsilon x) = \int^{(0+)} \frac{\exp(\epsilon x w)}{\{h(w)\}^{(m+1)/3}} \frac{dw}{2\pi i w^{m+1}} \,, \tag{2.4}$$

where

$$h(w) = \frac{6(\sinh w - w)}{w^3} = \sum_{l=0}^{\infty} \frac{6 w^{2l}}{(2l+3)!} \,.$$

Let us expand,

$$\{h(w)\}^{-(m+1)/3} = \{1 + g(w)\}^{-(m+1)/3} \tag{2.5a}$$

$$= \sum_{k=0}^{\infty} \frac{\{-(m+1)/3 - k + 1\}_k}{k!} \{g(w)\}^k \tag{2.5b}$$

$$= \sum_{k=0}^{\infty} \frac{\{-(m+1)/3 - k + 1\}_k}{k!} \frac{w^{2k}}{20^k} \sum_{l=0}^{\infty} C_{kl} w^{2l} \tag{2.5c}$$

$$= \sum_{n=0}^{\infty} a_n(m) w^{2n} \,, \tag{2.5d}$$

where

$$a_n(m) = \sum_{k=0}^{n} \frac{\{-(m+1)/3 - k + 1\}_k}{k!\, 20^k} C_{k,n-k} \,. \tag{2.6}$$

$$g(w) \;=\; h(w) - 1 = \frac{w^2}{20} \sum_{l=0}^{\infty} \frac{120 w^{2l}}{(2l+5)!} \,. \tag{2.7}$$

$\{g(w)\}^k$ is considered to be

$$\{g(w)\}^k = \frac{w^{2k}}{20^k} \sum_{l=0}^{\infty} C_{kl} w^{2l} \,. \tag{2.8}$$

# New method of calculating…(cont.)

From Eqs. (2.7) and (2.8), we get initial conditions:

$$C_{00} = 1\,, \qquad C_{0l} = 0 \qquad (l \geq 1)\,, \tag{2.9a}$$

$$C_{1l} = \frac{120}{(2l+5)!} \qquad (l \geq 0)\,. \tag{2.9b}$$

Again,

$$\{g(w)\}^{k+1} = \{g(w)\}^{k} g(w)\,. \tag{2.10}$$

From Eqs. (2.8) and (2.10),

$$\sum_{l=0}^{\infty} C_{k+1,l} w^{2l} = \sum_{l=0}^{\infty} C_{kl} w^{2l} \sum_{n=0}^{\infty} C_{1n} w^{2n} \tag{2.11}$$

which give the following recurrence relation

$$C_{k+1,l} = \sum_{n=0}^{l} C_{k,l-n} C_{1n}\,. \tag{2.12}$$

# New method of calculating…(cont.)

$n=0$

Finally, Eqs. (2.3) and (2.5d) yield

$$B_m(\epsilon x) = \int^{(0+)} \sum_{l=0}^{\infty} \sum_{n=0}^{\infty} \frac{a_l(m)(\epsilon x)^n w^{2l+n}}{n!} \frac{dw}{2\pi i w^{m+1}} \tag{2.13}$$

Applying Cauchy's integral theorem to Eq. (2.13), we get

$$B_{2m}(\epsilon x) = \sum_{n=0}^{m} \frac{a_{m-n}(2m)(\epsilon x)^{2n}}{(2n)!}. \tag{2.14a}$$

$$B_{2m+1}(\epsilon x) = \sum_{n=0}^{m} \frac{a_{m-n}(2m+1)}{(2n+1)!}(\epsilon x)^{2n+1}. \tag{2.14b}$$

**Using Eqs. (2.14a) and (2.14b), we can calculate $B_m(\epsilon x)$ numerically for any values of $m$.**

# Data Interpretation and Reporting

- At last you will get research data.
- It can be obtained by experiment or simulation or something else.
- It is important to interpretation or analyze research data for reporting or publishing.

# My suggestion to Graduate Students

- If you want to publish your research results then please select the journal carefully.
- Start with high impact journal first.
- If not succeed then try for Scopus indexed journal.
- Be patient ! Keep trying.

**Note: See two examples of my own experiences in next slide.**

# Example-1: Succeed after 5 times failure

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/bbe

ELSEVIER


Original Research Article

## Selecting the optimal conditions of Savitzky–Golay filter for fNIRS signal

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ABSTRACT

This paper proposes a method to find the best conditions for applying Savitzky–Golay (SG) filter to remove physiological noises from the functional near-infrared spectroscopy (fNIRS) signal. A narrative review on existing physiological noise reduction techniques from fNIRS signal demonstrates that the most common methods are window based finite impulse response (FIR) and SG filters. However, these filters did not clarify why and how it is able to remove noises from the fNIRS signal. This paper shows a systemic investigation of works

# Example-2: Succeed after 6 times failure

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## Design and implementation of smart guided glass for visually impaired people

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**ABSTRACT**

The objective of this paper is to develop an innovative microprocessor-based sensible glass for those who are square measure visually impaired. Among all existing devices in the market, one can help blind people by giving a buzzer sound when detecting an object. There are no devices that can provide object, hole, and barrier information associated with distance, family member, and safety information in a single device. Our proposed guiding glass provides all that necessary information to the blind person's ears as

“If we knew what we were doing, it wouldn’t be called research, would it?”

**Albert Einstein**

# Thank You