

1 **Research Methodology**

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2 **What Is Research?**

◆ Merriam-Webster's definition:

1 : careful or diligent search

2 : studious inquiry or examination; *especially* : investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws

3 : the collecting of information about a particular subject

3 **What Is Research? (Contd...)**

◆ "A combination of investigation of past work and effort in the present that will help others in the future"

◆ A set of opposites

■ Fun and frustration

■ Small steps and large insights

■ Building on others' work and contributing your own work

◆ Finding or developing something new that changes the world....

4 **Messages**

◆ Research:

■ Should be about some problem that encourages enthusiasm (for you) and interest (for others)

■ Is often generated from the thought "what we've got now/from the past isn't quite right/good enough – we can do better..."

■ Consists of work that leads to a meaningful contribution

■ Generates, in some way, a better solution to the problem

■

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5 **Benefits Of Doing PhD**

◆ Serving the Humanity by improving the knowledge; this is one of the biggest advantages and benefits of doing the PhD.

If your PhD is not doing in that direction you required to correct it.

◆ You will get Stability in your life

◆ You will get freedom (because of above two)

When you are free you will do lot of good jobs

◆ Phd is always being respected in the society.

6 **Thinking PhD...**

Queries you should have

◆ How To Choose A Best Guide For PhD?

■ Professor and lab. These two things guarantee a good PhD work and a strong career afterwards

◆ How To Choose A Good Place For PhD?

PhD in India as well as outside India

◆ Am I Suitable For PhD?

Does a PhD degree help me achieve the...








◆ Motivation Is Key For PhD Or Any Research Related Degree






◆

7 **Scope of Research**

◆ Varies by level of work

■ Ph.D. students – contribution expected at world level; e.g.

- background investigation on all past work
 - make meaningful addition to world knowledge
 - Undergraduate students – contribution can be at local to national to world level; e.g.
 - background investigation at university up to world level
 - make meaningful addition to university up to world level of knowledge
- 8  **What Isn't Research**
 - Playing with technology
 - Book report
 - Programming project
 - Doing what others have already done
 -
 - However, each of these can be done as part of research
- 9  **Who Does Research?**
 - Graduate Students
 - Masters Degree (lower standard)
 - Ph.D. Degree (higher standard)
 - Researchers at universities
 - Post-Doctoral students
 - Faculty members
 - Researchers in industry
 - Research scientists
 - Many other technical workers
 - Undergraduate students
- 10  **Who Does Research? (Contd...)**
 - Individuals
 - Teams
 - Teams almost always make the process easier
 - Division of labor
 - Feedback from team members
 - Each member can work to own strengths
- 11  **Problem Formulation**
 - Asking the right questions
 - Developing analytical models
 - Designing algorithmic descriptions
 - Discussions and brain storming with the supervisor and group
- 12  **How Extraordinary Creative Ideas Occur?**
 - Sudden spontaneous visions
 - Dreams
 - Cross-pollination from different fields
- 13  **Stories of Extraordinary Inventors** **Sudden Vision Discoveries**
 - Tesla's idea of the rotating magnetic field came to him instantly while he was walking in a park.
 - He drew a picture of the rotating magnetic field in the ground of the park.
- 14  **Stories of Extraordinary Inventors** **Sudden Vision Discoveries**
 - The great mathematician Gauss proved in an instant a theorem on which he had worked unsuccessfully for four years.

- "As a sudden flash of light, the enigma was solved. . . ."
- 15  **Stories of Extraordinary Inventors** **Dream Discoveries**
- ◆ Frederick Kekule fell asleep and dreamed of the benzene molecule as a snake biting its tail.
 - ◆ Otto Loewi had a dream that led to his discovery of the chemical transmission of nerve impulses.
- ◆
- 16  **Stories of Extraordinary Inventors** **Cross-pollination**
- ◆ Turbo codes by C. Berrou – electronics expert
1993 - "Near Shannon Limit Error-Correcting Coding and Decoding: Turbo Codes, *now widely used in satellites and high-speed networks*
 - ◆ Viterbi's algorithm – dynamic programming from computer science
A. J. Viterbi. Error bounds for convolutional codes and an asymptotically optimal decoding algorithm.
IEEE Trans. Information Theory, IT-13:260-269, 1967.
- 17  **Stories of Extraordinary Inventors** **Cross-pollination**
- ◆ Alan Turing (1912-1954)
(A pioneer of automata theory)
 - Father of Modern Computer Science
 - English mathematician
 - Studied abstract machines
Called *Turing machines* even before computers existed
 - Turing test: for machine intelligence
- 18  **Stories of Extraordinary Women Inventors**
- ◆ Frequency hopping
by Hedy Lamarr - famous actress
frequency hopping communication system, that was intended to control torpedoes without the enemy being able to discover what frequency was being used.
The solution, Hedy Lamarr and composer George Antheil reasoned, was a radio-controlled torpedo. But it would be easy for the enemy to jam a radio-control signal. So they cooked up something called "frequency-hopping." The trick was to set up a sequencer that would rapidly jump both the control signal and its receiver through 88 random frequencies. They patented the system and gave it to the Navy.
- 19  **Stories of Extraordinary Women Inventors**
- ◆ Dr. Grace Murray Hopper, Pioneer Computer Scientist
Ph.D. in Mathematics
COBOL Computer Language
From 1959 to 1961, Hopper lead the team that invented COBOL (Common Business-Oriented Language), the first user-friendly business computer software

program.

20 **Research Process – Initial Idea**

- ◆ Stems from critical thinking
- ◆ Be on the lookout for and open to seeing problems
 - Gaps in framework
 - Repetitive behavior that's slightly different (and can be generalized)
 - Manual solutions (that can be automated)
 - Inelegant solutions
- ◆ Ask questions
 - "Is something missing here?"
 - "Can this be done in a better way?"
 - "Is there a need for a new approach?"
- ◆ Should be an area you're interested in, as:
 - You'll be spending a lot of time with it
 - It won't always be easy/fun to continue...

21 **Research Process – Background Investigation**






- ◆ Given an idea, need to determine:
 - Has this work been done previously?
 - What similar work has been done leading up to this point?
 - How is any previous work distinguished from what I'm planning to do?
 - What group of people will be positively impacted by the research?
- ◆ Tools
 - Literature Review using library resources (e.g. online databases such as ACM and IEEE, popular magazines)
 - WWW search




22 **Research Process – Refinement of Idea**

- ◆ Based on background investigation, need to refine idea
- ◆ Issues:
 - Precision – focus on precisely identifying:
 - ◆ Problem
 - ◆ Possible solutions (plural!)
 - Scope – need to "build fences"
 - ◆ What's an essential part of this work? (fence in)
 - ◆ What's tangential, additional, or for any other reason best left for later/someone else? (fence out)

23 **Research Process – Core Work, Investigation and Development**

- ◆ Provide yourself with infrastructure
 - equipment / software
 - additional knowledge ("get up to speed")
- ◆ Do the work
 - Experimentation (scientific process)
 - Develop opinions
 - Look for better ways of solving problem
 - ◆ Can you generalize?
 - ◆ Can you develop a framework?
 - Discuss, brainstorm
 - Reevaluate as you proceed
 - ◆ Look for improvements, changes to your original ideas

- - ◆
- 24  **Research Process – Core Work, Investigation and Development (Contd...)**
 - ◆ Process
 - Work regularly
 - ◆ Easier to keep going if have a commitment to a regular work time
 - ◆ Helps you keep your past work in mind
 - Allocate large block of time for research
 - ◆ Takes time to get going/back to speed
 - ◆ Make sure can do something significant each work session
- 25  **Research Process – Core Work, Documentation**
 - ◆ Need to document as you go
 - Don't want to lose any information
 - ◆ 1) Maintain a journal for day-to-day thoughts
 - Can be paper, electronic, ...
 - Keep it with you at all times
 - ◆ Never know when good ideas will hit
 - ◆ 2) Keep an updated task list
 - Focus on accomplishing something each work session
 - ◆ 3) Write up your work
 - Periodically, write a few pages on a subset of your work
 - ◆ Summarize work, accomplishments, problems
 - At end, write up a summary document
 - ◆ Can be based on steps discussed here
- 26  **Research Process – Core Work, Prototype**
 - ◆ Need to demonstrate the merit of your ideas
 - ◆ If work is non-theoretical, do this through a developed system
 - No need to build the entire system
 - Just need to demonstrate the value of the core ideas
- 27  **Research Process - Evaluation**
 - ◆ Perhaps the most difficult part...
 - Best if can show others are already using your work
 - ◆ For Quantitative research
 - (Quantitative – use of statistical, formulaic or numerical analysis to generate results
 - Main approach: analysis; causal determination, prediction, generalization of findings
 - Results: "This solution is N% better")
 - Test your prototype
 - What improvements exist over currently available alternative?
 - How much of an improvement do you see?
- 28  **Research Process - Evaluation**
 - ◆ Perhaps the most difficult part...
 - Best if can show others are already using your work
 - ◆ For Qualitative Research:
 - (not quantitative; use of non-numeric techniques
 - Main approach: discovery; illumination, understanding, extrapolation to similar circumstances
 - Results: "This is a new way of solving our problem")
 - ◆ What can you do now that couldn't be done before?
 - ◆ What are the benefits of your solution?

- 29  **Research Process – Identification of Future Work**
- ◆ Helps you organize any future efforts
 - ◆ Helps others build on your work
 - ◆
 - ◆ Sources:
 - What you excluded in your idea refinement
 - New problems that have surfaced during your work
- 30  **Research Process - Presentation**
- ◆ It's not a contribution to the field if no one knows about it or can use it
 - ◆ Presentation/Dissemination
 - Conferences, Journals, Web
 - ◆ e.g. National Undergraduate Research conference
 - Papers, Talks, Poster Sessions
- 31  **Thank You**