

Research Methodology

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Effective Use of Literature

- Two hours spent in the literature Survey now may save two months or even two years of wasted effort later
- Be sure that nobody has already done what you propose to do, and make sure there aren't good reasons as to why you should not try
- Read with a specific goal in mind and make notes as you read. Don't just go through a large numbers of papers superficially and indiscriminately
- Keep full and consistent bibliographical records of what you read. This can save an enormous amount of frantic last-minute effort
- Find out what format people in your group or field use to record citations. Begin to create an annotated list of citations in this format from the very start of your research

Some Tips

- Identify the key journals in your field, and keep an eye on the recent issues
- Experiment or find out which search engines your colleagues use to monitor the literature
- Consider joining or forming a reading club, where a group of students gather each week to discuss a recent relevant paper

Some Tips Contd.

- For a really deep understanding, reading a paper once is not sufficient. You should read it several times and get involved in it
- One invaluable way to get a deep understanding of some work is to try to teach it to others. Offer a seminar, either formal or informal
- When reading a paper you will find that you understand it better if you have a question in mind which you hope the paper will answer. Ask:
 - 1 What claim is being made?
 - 2 What is the evidence for this claim?
 - 3 Is it convincing?
 - 4 How can I use this work in my own research project? etc.

- Finally don't be afraid to admit your ignorance by asking questions
 - 1 Get in touch with the author(s) about it. Talk or write to them with a list of queries and/or criticisms
 - 2 You can usually get a far better feel for a piece of work by engaging in a discussion with someone who understands it than just by reading the paper alone

Write while you collect and collect when you write

- Literature review should not be a linear process, which has a start and an end
- It can be described as collecting, reading, reviewing and writing about the literature cyclically
- Reading widely helps to
 - clarify the research focus and research questions
- Revisiting and clarifying your research focus and questions allow you to
 - refine your literature search and collection
 - to identify what literature you need to explore in more depth
 - and what gaps there are in the literature you have explored to date

Write while you collect and collect when you write contd.

- Writing about the literature acts as a way of learning about the literature.
- Waiting to write about the literature until you have read 'everything' can easily become unwieldy and unmanageable
- Writing as you go along offers a way of creating a dialogue, which can be between you and your reading, between you and your supervisor, and between you and other researchers
- First attempts at writing will be a way of beginning to understand the literature
- While putting down in writing, the gaps in knowledge would be better realized
- This would prompt more critical reading leading to refined and deeper understanding

Introspections during Survey

- What type of literature review am I conducting?
- Am I looking at issues of theory? methodology? policy? quantitative research (e.g. on the effectiveness of a new procedure)? qualitative research (e.g., studies)?
- Is the survey aimed to define my problem, refine it or improve? What is the scope of my literature review?
- What is the scope of my literature review?
 - Temporal, subject/topic?
- How good was my information seeking?
 - Completeness, scope, sources , focussing
 - Have I cited and discussed studies contrary to my perspective?
 - Will the reader find my literature review relevant, appropriate, and useful?
 - Have I critically analysed the literature I use?
 - Do I assess them, discussing strengths and weaknesses?

Research Design

Can Research Be Designed?

The truth is:

“PhD research is not for Nobel Prize; it is more about training of scholars. The research outcome of a PhD research is just a validation of the training. A training scheme can certainly be designed.”

I know that, you know that, but does my supervisor know this?

- Despite the divergence of opinion, everybody would agree that a plan/pattern or a scheme would be useful for a research project
- Consider construction of a building; one cannot order materials or set critical dates for completion of project stages until at least the type of building is being constructed is known
- Depending on whether it is an office building, a factory, a school, a residential home or an apartment block. we can sketch a plan, create bill of materials and work out a work schedule

- The research design depends on the type of research question
- There are two types of approach
 - 1 Top Down
 - 2 Bottom Up
- Experienced supervisors tend to prefer the top down approach.

Top Down Approach

- In TOP DOWN approach, first step is to find research question(s)
- it may happen that there are many focal research questions inside a research question
- Picture in the next page will explain it clearly

Research Question(s)

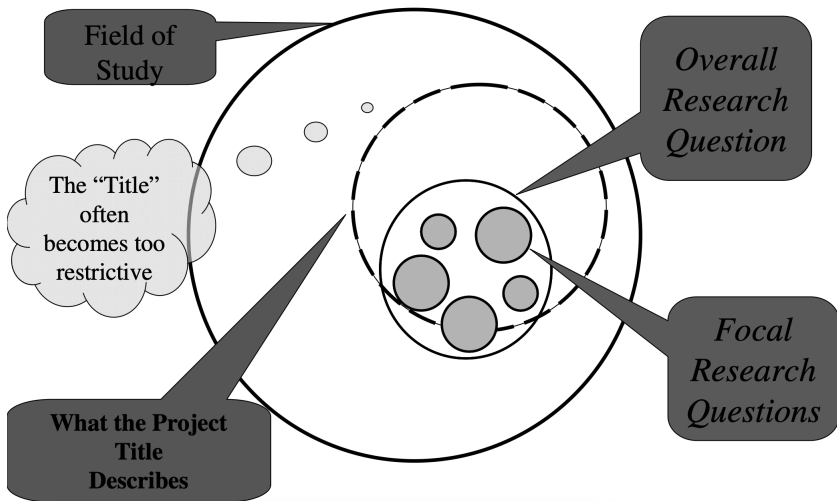


Figure:

Research Questions Contd.

- The connection between the overall and focal research questions has an important role to play in the research design
- In the simplest case, the global question is just a union of the focal questions, e.g. to prove humans are mammals, we need to prove that both the male and female species are mammals
- You might have noted that union of questions means all the questions to be answered. That is, all the underlying propositions are AND-ed

Research Questions Contd.

- With the global question becoming a pure union, the work content increases and becomes quasi- parallel threads
- Most often the relation is more complicated, having a sequential and parallel pathways
- For example: To prove A, you have to prove first B else prove Both C and D. If B fails, one need to go for C and D

- The major Types of Research questions encountered in Science, Engineering and Technology are of the following kinds
 - 1 Descriptive Research Questions
 - 2 Explanatory Research Questions
 - 3 Design questions
 - 4 Remediation question

Scientific Method to Find/Redefine Research Question(s)

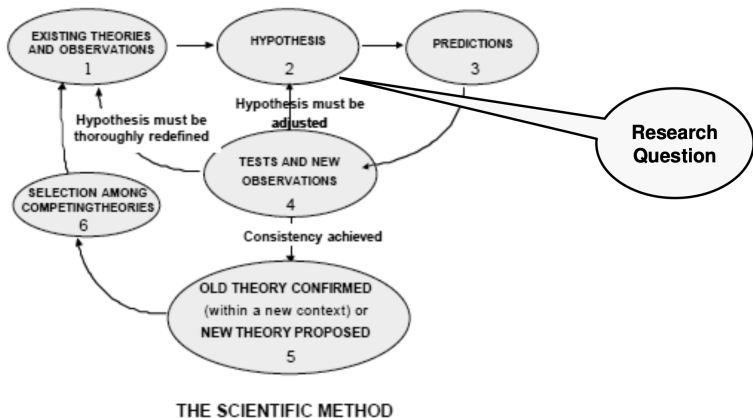


Figure:

Problem Decomposition

- It begins with the ultimate goal of the project (the Overall Research Question), and explicitly derives design decisions by “working downwards” from this overall purpose
- Assume that the overall research problem is one of:
 - ① Testing-out Research
 - ② Exploratory Research
 - ③ Problem solving Research
- For Testing out Research and Problem Solving Research “Working Downwards” in problem decomposition means identifying the chain or branching tree of sub-goals (focal questions) that links the ultimate goal
- The sub-goals may have to be further decomposed
- For Exploratory Research problem decomposition will result in two or more alternative goals
- Each of which may again have to be decomposed

Problem Decomposition Contd.

- The decomposed components and focal questions may be decoupled or serially coupled
- Decoupled components may be solved in parallel
- Serially coupled components must be solved one after the other

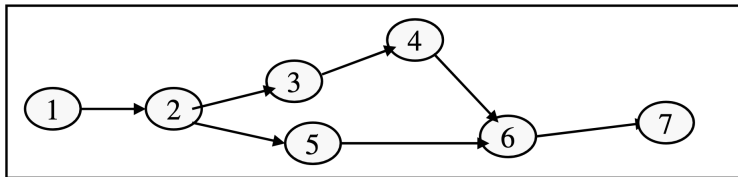


Figure:

Advantages of Decomposition

- The decomposition diagram becomes a template for project
- The decomposed focal questions may correspond to chapters of thesis
- Different strategies may be employed for each component depending on the respective types
- The type of statistical tools required for each quantitative component tend to be simple and robust as issues with smaller scopes and nearly independent need to be tackled
- A better estimation of time and effort is possible
- A better choice of selecting a problem is possible for exploratory research

How to Decompose a Problem

- Decomposition of a problem requires a substantial understanding of the problem
- Paradoxically, decomposition allows a better understanding of the problem
- The first step to problem decomposition is literature survey which leads to a better understanding and the ability to define the problem with increased clarity
- Imagination, brain storming and thought experiments, are also useful for problem decomposition

Search For Neighbouring Problems

- Similar previously reported work that exists within the boundary
- Such a previous work is called as a neighbouring problem
- Decomposition of a neighbouring problem would usually be available in the literature, which could be used as a starting point for decomposition

Example

- Research Problem: Randomness Testing of given sequences
- Try to find out literatures on randomness testing
- Identify how those literatures decompose the overall problem
- You may find a large number of tests available, e.g. NIST, Dieharder, ENT, name a few
- Each of these tests will be your focal points
- You need to explore those tests on your sequences and analyze the results for solving your overall problem

Problem Decomposition: Summary

- Problem Decomposition is the most important aspect of top down research design
- Problem decomposition is to be carried out iteratively
- This step may require one month to six months depending on
 - Type of the problem
 - Thoroughness of literature survey
- It provides many benefits including
 - Better understanding of the problem
 - Better planning
 - Downstream research design
- Tools of decomposition are:
 - Literature Survey
 - Brain storming and thought experiment

Bottom-Up Approach

- Research often happens in a contingent path rather than in a designed path
- One such contingent path is Bottom up Research
- In the Bottom up Research approach a decision is taken to study, say X
- Possibly a new instrument Y is available which allows experimenting on X and collecting a huge amount of data
- The research design consists of
 - Listing the possible data that can be generated
 - Chalking out the steps in conducting experiments
 - Performing the experiment to collect data
 - Choosing suitable statistical methods to process the data
 - Arriving at conclusions based on statistical findings.

Bottom-Up Approach Contd.

- This style of research design can be called bottom-up, because it begins at the lowest level, with a specification of what to observe or measure
- Though there are serious criticisms about this approach, this is a viable approach for PhD research
- Pros of bottom up research:
 - Student remains continuously engaged
 - Student knows exactly what to do
 - Intermediate analysis and data may be publishable

- Cons of Bottom Up Research:
 - Mostly applicable to empirical research
 - A weak variant is possible for theoretical research
 - It is only after huge quantities of data have been gathered and recorded that the investigators begin seriously to think about analysis and conclusion
 - The data gathered has no end use in view and much of the data may have to be just rejected as such data may prove inconclusive (does not prove or disprove any hypothesis)
 - An unplanned intermediate data collection may not result in publication

Cons. of bottom-Up Approach

- "Thinking about analysis" usually means searching for a statistical tool which will transform their huge miscellaneous data into neat figures and "some significant statistics"
- A research hypothesis is usually framed post hoc, that is after getting some statistics, if some statistical measures support such hypothesis
- The reverse engineering of generating hypotheses from data is often a difficult proposition
- Important training elements in PhD research may be missing

Top Down Research Design Suggested By Lane Cobb

- The six steps in top-down design
 - 1 Write a single-sentence summary of the main result your research is intended to produce (as it might be stated in a literature review by some future scientist who is citing your research)
 - 2 Write an tentative abstract for the paper that reports the result quoted in Step 1; Abstract will be modified as your research progress; actual statistic can be given later
 - 3 Draw the figure or table that conclusively establishes the main result claimed in Step 2; these will also be revised/filled with actual numbers

Top Down Research Design Suggested By Lane Cobb Contd.

- 1 Write down every realistic way in which the validity of the figure or table in Step 3 can be criticized;
 - Use this list to identify the controls and comparisons needed in the (research design) to counter these doubts
- 2 Draft the research methods section for the paper
- 3 Flesh out the full research design, using Step 5 as a guide. Do not include anything not demanded by Step 5! Design the structure of the data so that these figures or tables are readily derivable

Writing a Research Proposal

- A project is somewhat involved task, typically spanning three months to 3 years.
- It involves:
 - 1 Focused activities
 - 2 Planning
 - 3 Resources like money, equipment, manpower
- A research project proposal is a document which
 - 1 can convince a funding agency (evaluation)
 - 2 can act as a guideline for implementation
 - 3 may be used as a vehicle for refinement of the plan

Why Write Research Proposal?

- Learn how to
 - 1 For personal growth, teachers need to get involved in research for which funding is required
 - 2 Funding is also required to improve laboratory and other infra-structure of the institution
 - 3 Conventional budgetary provisions are either non- existing or inadequate
 - 4 Alternative funding sources must be explored and research proposals submitted to them
 - 5 Even for grant-in-aid utilization, a project plan should be prepared and adhered to

Why Write Research Proposal?

- It will help to understand
 - ① Researcher's interest,
 - ② Researcher's competence,
 - ③ Researcher's own resource
 - ④ Researchability of the problem
 - ⑤ Importance and Urgency
 - ⑥ Novelty of the Problem
 - ⑦ Feasibility
 - ⑧ Facilities
 - ⑨ Usefulness and
 - ⑩ Social Relevance

Funding Agencies for Research Projects

- For All :
 - ① UGC
 - ② State Govt.
 - ③ Local self Governments
- International Body:
 - ① UK agencies
 - ② European Union
- For Humanities
 - ① Respective councils
 - ② Trust funds

Funding Agencies for Research Projects Contd.

- For Science and Technology
 - 1 CSIR
 - 2 DST
 - 3 Dept of Space
 - 4 BRNS
 - 5 State S&T
- For Technology
 - 1 AICTE
 - 2 DRDO
 - 3 Large Enterprises
 - 4 Chambers of Commerce and Industries

Perspectives of the Funding Agency

- The project objectives should match with the objectives of the funding agency
- Project outcomes should be visible and measurable
- The project should be well planned
- Project team members have adequate knowledge and capabilities
- The budget and time frame should be reasonable

Example

Project Proposal Life Cycle

- Project Idea
- Pre-proposal
- Finding prospective funding sources
- Project Proposal submission
- Scrutiny
- Peer review
- Presentation and board review
- Sanction
- Execution and Monitoring
- Closure with utilisation certificate

The Idea

- A project proposal is born from an idea
- The idea could of many different kinds
- An opportunity to solve an important but unsolved problem
- Using a novel method for solving an important problem
- Discovering pattern from apparently random
- Analyzing root cause of some problem, phenomenon, happenings etc.
- Challenging existing theories in the light of new data or findings
- From the idea, it would be possible to
 - Write the aims
 - Articulate the motivation

Defining and Formulating the Research Aim

- Formulation is the process of refining the research ideas into research questions and aims
- Formulation means translating and transforming the selected research problem/idea into a scientifically researchable question
- It is concerned with specifying exactly what the research problem is

Defining and Formulating the Research Aim Contd.

- The Aim is a more concrete form of the idea
- The aim tells others and yourself, why the project is worth doing
- Articulation of AIM could be a challenging task
- You should be excited about it (feel motivated)
- Some sponsors would also feel that it is worth funding
- It must be written down and pondered over many times

- Research Aims should be clear and achievable, as they directly assist in answering the research problem
- The aims may be specified in the form of either statements or questions
- Generally, they are written as statements, using the word “to”
- For example, ‘to discover ...’, ‘to determine ...’, ‘to establish ...’, etc.

Aligning the Aim

- The articulated Aim should be aligned to meet
 - Motivations of the researcher
 - You should feel that taking up the project is worthwhile
 - Capability of the researcher
 - Time frame
 - Facilities already available
 - Requirements of the sponsor(s)
- If the aim is aligned and the researcher is capable, the main hurdle is out of the way
- Some of the sponsors (MeitY, DST, BRNS) design the “proposal form” to help alignment.

Project Summary

- The summary should be no more than one page, and should provide the reader with a quick overview and a reason for him or her to read the rest of the proposal.
- It should include:
 - Clear signals that this is an important document that the reviewer should read
 - The project is addressing an important problem that needs solving
 - The project will make a significant contribution to solving the problem, and it will be done in a sensible, feasible and cost effective manner
 - The Investigators (PI and Co-PI) are well prepared to implement the project

Project Outcomes

- To meet project Objectives, a number of outcomes would be necessary
- Outcomes/Outputs/deliverables need to be stated in such a way that:
 - Their realization can be identified, in terms of quantity, quality, time and place
 - The entire project cycle can be subdivided into several milestone
 - Each milestone will be defined by time line; for example, Milestone I might denote the initial six months of the project
 - All outputs necessary for achieving the milestone should be listed and all outputs clearly relate to the immediate objective

Common Problem in Defining Outcomes

- It is common to confuse the objectives and the outcomes
- Outcomes are also commonly confused with activities
- Remember that an output is the result of an action or activity
- Often the expected outcomes of a project is presented in a long list, with no clear indication of how each result relate to immediate objectives and activities
- This makes it very difficult for the reviewer to understand the relevance of the proposed outputs and activities, and also difficult to judge the feasibility of the project
- A simple system of numeration can solve this e.g. objective 1, result 1.1, 1.2 and activity 1.1.1, 1.1.2 etc.

- This should contain
 - 1 The problem or opportunity to be addressed
 - 2 The significance and extent of the problem
 - 3 E.g., how many people are affected, how they are affected, and how will they be affected in the future? Are they poor, and or vulnerable?
 - 4 The identified causes of the problem
 - 5 What has been done in the past to address the problem and its causes
 - 6 How the present proposal is different from past initiatives
 - 7 A Literature Survey would generally be required

- Each deliverables would require activities/tasks which would generate them
- Outcome should be matched to the tasks required to accomplish them
- This is the best done by listing the goals/outcomes on the left side of a sheet of paper, then writing the tasks to their right
- The tasks should be clearly understandable from nomenclature or explanatory notes must be added
- Functional Decomposition is a helpful tool

- After the tasks are identified, one must find the sequence in which these must be executed
- This is done with the help of charts, e.g., Gant Chart, PERT Chart etc.
- The Gant chart is the more simpler
- A Gant chart shows the activities against a time line
- A Gant Chart must be drawn after a careful analysis of dependencies

- Components of the Budget:
 - ① Recurring Expenditure
 - ② Capital Expenditure
- Capital Expenditure
 - ① Equipment Purchase
 - ② Storage/furniture
 - ③ Building
- Recurring Expenditure
 - ① Salaries and Fellowships
 - ② Annual Maintenance
 - ③ Contingent expenditure (postage, stationary, local travel)
- Contingent expenditure should not typically exceed 10-15% of total grant of the project

- Most project proposal formats require to include the CV of the applicant(s)
- Funding agencies would like to know the past track record of the applicant(s)
- And evidences to suggest that the applicant(s) are capable of completing the project objectives successfully
- The evidences of capability are:
 - 1 Publications
 - 2 Experience in executing projects of comparable magnitude and complexity
- To strengthen this aspect, teaming up with other experienced researchers may be necessary

- T. K. Ghoshal, Research Methodology, Jadavpur University, 2013