Research Question, Hypothesis, Objectives

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References

- S. Finger, Advice on Writing Proposals to the National Science Foundation, Carnegie Mellon University, April 2015
- Adventures in Grantseeking: NSF, TAMU – Texarkana, May 2018
- G. A. Hazelrigg, Honing Your Proposal Writing Skills, National Science Foundation
- NSF, A Guide for Proposal Writing
- 2013 NSF CAREER Proposal Writing Workshop, University of South Florida
- Grant Proposals (or Give me the money!), The Writing Center, University of North Carolina at Chapel Hill
- Art of Grantsmanship, Human Frontier Science Program
- A. M. Coelho, Jr., Formula for Grant Success, <https://www.youtube.com/watch?v=A1Zb5I17qGs>
- Writing Guide for NSERC Grant Applications, The Word Company, Ottawa
- T. M. Pinkston, Academic Career Workshop: Writing Research Proposals, USC
- Regents of the University of Michigan, Updated in 2014 by Christine Black (Originally produced by Don Thackrey)
- Principal Investigators Association, Executive Report: How to Write a Winning NSF Proposal
- University of Sheffield, Technical Report Writing for Engineers
- https://www.futurelearn.com/courses/technical-report-writing-for-engineers/0/steps/40128
- https://www.thebalancesmb.com/writing-goals-for-grant-proposal-2501951
- S. A. Jones, Proposals, Biomedical Engineering, Louisiana Tech University
- https://www.editage.com/insights/how-to-write-a-problem-statement-for-my-research
- https://chandoo.org/forum/threads/the-connections-between-milestone-activities-deliverables-project-phase.16738/
- Univ of Michigan, The Proposal Writer's Guide: Overview
- UNISA, Engineering research project: proposal
- Elena Kallestinova, How to Write a Compelling Grant Abstract, Yale Center for Teaching and Learning
- RT Erasmus, Writing a Grant Funding Proposal: General Overview, Choosing the topic, Abstract and Executive Summary

- The overall purpose of a study can be expressed in three ways:
  - as research questions
  - as hypotheses
  - as aims and objectives

  or a combination of these.

- Whether to use questions or hypotheses → depends on factors such as
  - Purpose of study
  - Nature of design and methodology
  - Audience of research (even taste and preference of reviewers, committee members, the Chair)

Research Question

The first step is to define the research problem → *most difficult and important step*

- What are known
- What are not known → knowledge gap
- Knowledge gap leads to research problem
- Present research problem in the form of questions

- A research problem → an area of concern or a *gap in existing knowledge*
  ⇒ points to need for further understanding and investigation
- Identify and state the problem in *specific terms*
- Identify *variables* in the problem situation and define them adequately
- Generate explicit research questions on relationships between important variables

Do not paint the problem in general terms:

- ***"little is known about ..."***
- ***"no research has dealt with ..."***

Examples of research questions: Try putting different words in blanks...

1. What is the effect of _____ on _____?

detergent ------- germination of seeds
temperature--------the volume of air

2. How/to what extent does the _____ affect _____?

humidity----------growth of fungi
color of a material----------its absorption of heat
fertilizer ----------the growth of plants

3. Which/what _____ (verb) _____?

detergent---------- makes ----------the most bubbles

Research questions →
- precise and specific
- state exactly what you are going to investigate

Problem statement

- A problem statement → a claim that outlines and briefly explains the problem; briefly addresses the research question
- Transform a generalized problem into a targeted, well-defined problem that can be resolved through focused research

Characteristics of a problem statement

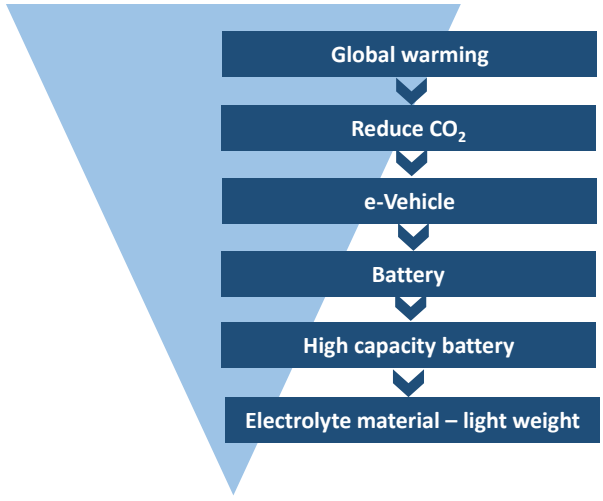
- Address a gap in knowledge → What have been done in the past, and why further research is needed
- Identify and delineate research problem → Problem should render itself to investigation through collection of data
- Explain what researcher wants to solve and what questions he/she wishes to answer
- Convincing argument that available knowledge is insufficient to solve it
- Explains why the study is important
- Problem statement forms a foundation for further development of research proposal → Objectives. Methodology etc.

Main drawback of many proposals: ***Research question is not specific enough***

Group discussion

Look into your own research question(s). Are these specific enough ?

Hierarchy to be considered while framing research problem, question etc



Research problem into question

Example research problem	Example research question(s)
The teachers at school X do not have the skills to recognize or properly guide gifted children in the classroom.	What practical techniques can teachers at school X use to better identify and guide gifted children?
Under-30s increasingly engage in the "gig economy" instead of traditional full-time employment, but there is little research into young people's experiences of this type of work.	What are the main factors that influence young people's decisions to engage in the gig economy? What do workers perceive as its advantages and disadvantages? Do age and education level have an effect on how people experience this type of work?

Research question: example

Research question	Explanation
• What effect does social media have on people's minds?	The first question is not specific enough: what type of social media? Which people? What kind of effects?
• What effect does daily use of Twitter have on the attention span of under-16s?	The second question defines its concepts more clearly. It is researchable through qualitative and quantitative data collection.

Research question: example

Research question	Explanation
• Has there been an increase in homelessness in San Francisco in the past ten years?	The first question is too simple: it can be answered with a simple yes or no.
• How have economic, political and social factors affected patterns of homelessness in San Francisco over the past ten years?	The second question is more complex, requiring in-depth investigation and the development of an original argument.

Research question: example

Research question	Explanation
• How can drunk driving be prevented?	The first question asks for a ready-made solution, and is not focused or researchable.
• What effect do different legal approaches have on the number of people who drive after drinking in European countries?	The second question is a clearer comparative question, but note that it may not be practically feasible. For a smaller research project or thesis, it could be narrowed down further to focus on the effectiveness of drunk driving laws in just one or two countries.

Hypothesis

Hypothesis

- An educated guess about how things work
- Declarative statement → predicts relationship between two or more variables, concepts, phenomena, things, events, etc.
- Predict a possible answer to the research problem or question
- "If-Then" statement → underlies whole research study
- Testable → you need to be able to measure both "what you do" and "what will happen."

Hypothesis formulation

- Identify and state the problem in *specific terms*
- Identify the *variables* in the problem situation and define them adequately
- Generating tentative guesses (***hypotheses***) about the relation of the variables or in other words the solution of the problem

A hypothesis is usually written like this:

"If _____[I do this]_____, then _____[this]_____ will happen."

(Fill in the blanks with the appropriate information from your own experiment.)

Example:

If soil temperatures rise, then plant growth will increase.

This leads to objective:

To study the effect of soil temperature on plant growth

Another example of a hypothesis:

"If rampart craters on Mars form because of groundwater, then we should see a correlation between groundwater and rampart crater distributions. "

Research Question vs Hypothesis

Research Questions

- Mostly used in qualitative research, although used nowadays in quantitative research
- Pose relationship between two or more variables → phrases relationship as question

Hypotheses

- Typically used only in quantitative research
- Based on theoretical framework
- Represents a declarative statement of relations between two or more variables (Kerlinger, 1979; Krathwohl, 1988)

Example:

Research Question:
What effect does sleep inertia have on the ability to detect change on a visual display?

Hypothesis:
Sleep inertia impairs the ability to detect change on a visual display.

Research Objectives

- *Goals/aims are broad statement of what is ultimately to be accomplished*
- *Objectives are more specific aims which the project wants to achieve*

Goal / Aim

- Overall concept, more abstract
- Broad statement of what you want to accomplish

VS

Objectives

- S – Specific
- M – Measurable outcomes
- A – Achievable, attainable
- R – Realistic
- T – Time-bound, achievable in a specified time period

Goals/Aims are:

- Big and broad, even visionary
- General intentions
- Intangible
- Abstract
- Hard to measure

Objectives are:

- Narrow
- Precise
- Tangible
- Concrete
- Measurable

Characteristics of Objectives

- State objectives as outcomes/solution, not as process
- Objectives should specify the result of an activity
- Must collectively test all parts of hypothesis
- Two to five at the most
- Each must flow logically into the next
- None should be absolutely dependent on the outcome of an earlier objective

Research objective should lead to your methodology → If it does not, research objectives are not good enough

Objective can be written in different ways

The research objective of this proposal is to:

- test hypothesis H
- measure parameter *P* with accuracy *A*
- prove conjecture *C*
- apply method *M* from disciplinary area *Q* to solve problem *X* in disciplinary area *R.*

Examples of objectives:

- The research objective of this project is to measure the cross-section of the muon-nutrino interaction at 5 GeV accurate to 5%.
- The research objective of this proposal is to test the hypothesis that physical phenomena x,y,z dominate the chip formation process in the machining of brittle materials.

Example of aim and objectives

Aim

"The aim of this project is to determine how the elastic behaviour of a piece of bungee cord varied with applied load".

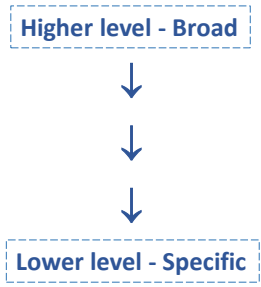
Objectives

1. To examine the relationship between spring constant and applied load.
2. To calculate the natural frequency from spring constant values, at various loads.
3. To compare an experimental value of natural frequency with a predicted value.

These words in objectives may not mean "fundamental research"

- Develop
- Design
- Optimize
- Control
- Manage

Hierarchy of objectives



Long term goal/aim: broad
To reduce birth defects among children of farm workers

Overall objective: narrower
To determine the cause of environmentally linked cleft palate (leap) syndrome

Specific Objective: narrowest
To determine the effect of herbicide "X" on the occurrence of cleft palate (leap) syndrome

Summary

Action Verbs for SMART GOALS

Accelerate	Collect	Enact	Inform	Outline	review
Accompany	Command	Encourage	Initiate	Participate	revise
Achieve	Communicate	Enforce	Innovate	Perceive	Schedule
Acquire	Complete	Engineer	Inspire	Perfect	Screen
Adapt	Compose	Enhance	Install	Perform	Secure
Address	Conceive	Employ	Instruct	Persuade	Select
Adjust	Condense	Establish	Insure	Pilot	Serve
Administer	Conduct	Evaluate	Integrate	Pinpoint	Simplify
Advance	Construct	Exceed	Intensify	Pioneer	Solve
Advertise	Contract	Execute	Interpret	Place	Spearhead
Advise	Contribute	Exhibit	Interview	Plan	Specialize
Advocate	Control	Expand	Invent	Prepare	Staff
Allocate	Convert	Expedite	Investigate	Preside	Standardize
Analyze	Cooperate	Explain	Justify	Prevent	Streamline
Anticipate	Coordinate	Explore	Launch	Prioritize	Strengthen
Apply	Correlate	Facilitate	Lead	Process	Structure
Appreciate	Correspond	Finalize	License	Procure	Succeed
Arrange	Create	Finance	Locate	Produce	Summarize
Assemble	Cultivate	Focus	Log	Program	Supervise
Assess	Customize	Forecast	Maintain	Project	Support
Assign	Decide	Formalize	Manage	Promote	Survey
Assist	Define	Form	Manufacture	Propose	Synthesize
Audit	Delegate	Foster	Market	Prove	Systematize
Authorize	Deliver	Found	Master	Provide	Tabulate
Balance	Demonstrate	Fundraise	Mediate	Publicize	Target
Brief	Design	Generate	Mentor	Publish	Teach
Budget	Determine	Govern	Minimize	Purchase	Test
Build	Develop	Graduate	Mobilize	Qualify	Train
Calculate	Devise	Guide	Modify	Quantify	Transfer
Catalogue	Direct	Handle	Monitor	Realize	Transmit
Centralize	Discover	Head	Motivate	Recommend	Translate
Chair	Display	Hire	Negotiate	Reconcile	Tutor
Change	Document	Identify	Nominate	Recruit	Unify
Clarify	Double	Illustrate	Obtain	Reduce	Update
Classify	Draft	Implement	Officiate	Reinforce	Upgrade
Collaborate	Earn	Improve	Operate	Reorganize	Use
Collect	Edit	Improvise	Orchestrate	Report	Utilize
Command	Educate	Incorporate	Order	Research	Verify
Communicate	Effect	Increase	Organize	Resolve	Volunteer
	Eliminate	Influence	Originate	Respond	
				Revamp	