

Research Problem Formulation

Gaps or viable research directions (for science and engineering)

Consider an existing method or knowledge about a topic. Identify its intended and current use. Figure out how satisfactorily the method or knowledge meet the expectations. Can there be improvements in quantitatively or qualitatively?

With respect to a method, one may seek alternatives that are-

- more efficient,
- some less expensive alternatives
- more usable, behaviorally, environmentally, ethically,
- more robust,
- safer.

In the current applications what are the failure situations, or are there some situations that are not covered/explained by the existing technology or science.

Take cues from current technologies, identify related technologies, and imagine what other technologies might be possible. Technology is based on science, hence for a newly imagined technology, figure out whether the required scientific knowledge is there. If the scientific knowledge exists then research can focus on developing the new technology. Otherwise, research on the scientific angle can be undertaken stating the potential applications, i.e., the technology visualised.

Hypothesis

A hypothesis is a supposition or proposed explanation made on the basis of limited evidence, without any assumption of its truth, as a starting point for further investigation. It is an educated guess about how things work. A hypothesis should be something that one can actually test, what's called a **testable** hypothesis.

A scientific hypothesis is the initial building block in the scientific method. Many describe it as an "educated guess," based on prior knowledge and observation, as to the cause of a particular phenomenon. It is a suggested solution for an unexplained occurrence that does not fit into current accepted scientific theory. A hypothesis is the inkling of an idea that can become a theory, which is the next step in the scientific method.

The basic idea of a hypothesis is that there is no pre-determined outcome. For a hypothesis to be termed a scientific hypothesis, *it has to be something that can be supported or refuted through carefully crafted experimentation or observation.*

Often a hypothesis is written like this:

"If ____ [I do this] ____, then ____ [this] ____ will happen." (Fill in the blanks with the appropriate information from your own experiment.)

A key function in this step in the scientific method is deriving predictions from the hypotheses about the results of future experiments, then performing those experiments to see whether they support the predictions.

The primary trait of a hypothesis is that something can be tested and that those tests can be

replicated. A hypothesis, is often in the form of an if/then statement, and in many cases hypotheses do not become theories as it is difficult to gather sufficient supporting evidence within the given investigation framework.

Upon analysis of the results, a hypothesis can be rejected or modified.

As sufficient data and evidence are gathered to support a hypothesis, it becomes a working hypothesis, which is a milestone on the way to becoming a theory.

A working hypothesis is a hypothesis that is provisionally accepted as a basis for further research in the hope that a tenable theory will be produced, even if the hypothesis ultimately fails. Like all hypotheses, a working hypothesis is constructed as a statement of expectations, which can be linked to the exploratory research purpose in empirical investigation and is often used as a conceptual framework in qualitative research. A group of hypotheses together may form a conceptual framework.

Working hypotheses - to facilitate inquiry; however, formal hypotheses - based on the results of the inquiry, which in turn allows for the design of specific experiments whose data will either support or fail to support the formal hypotheses.

An interesting case is that of conjectures in mathematics – propositions which appear to be true but which are formally unproven. Very often, conjectures will be provisionally accepted as working hypotheses in order to investigate its consequences and formulate conditional proofs.