

The MTU MSE Qualifier

Two types of research proposals

Exploratory: “we think we can make something better or find out what is going on in this interesting area if we try a bunch of things and apply several sophisticated techniques to study this”. These proposals are pretty easy to write, but the undisciplined nature of the research may result in significant waste.

Hypothesis based: “This area has a particular point with a lack of understanding. Based on the previous studies, we think this explanation applies here. We propose these experiments to test this explanation”. These proposals are very hard to write, but the inherent design forces a conclusion with efficient use of resources.

Michigan Tech MSE has decided to strongly emphasize hypothesis based research in the PhD qualifier.

Wiki definition

A **hypothesis** is a proposed [explanation](#) for a phenomenon. For a hypothesis to be put forward in science or engineering, the [scientific method](#) requires that one can [test](#) it.

Scientists/Engineers generally base **hypotheses** on previous [observations](#) that cannot satisfactorily be explained with the available scientific theories.

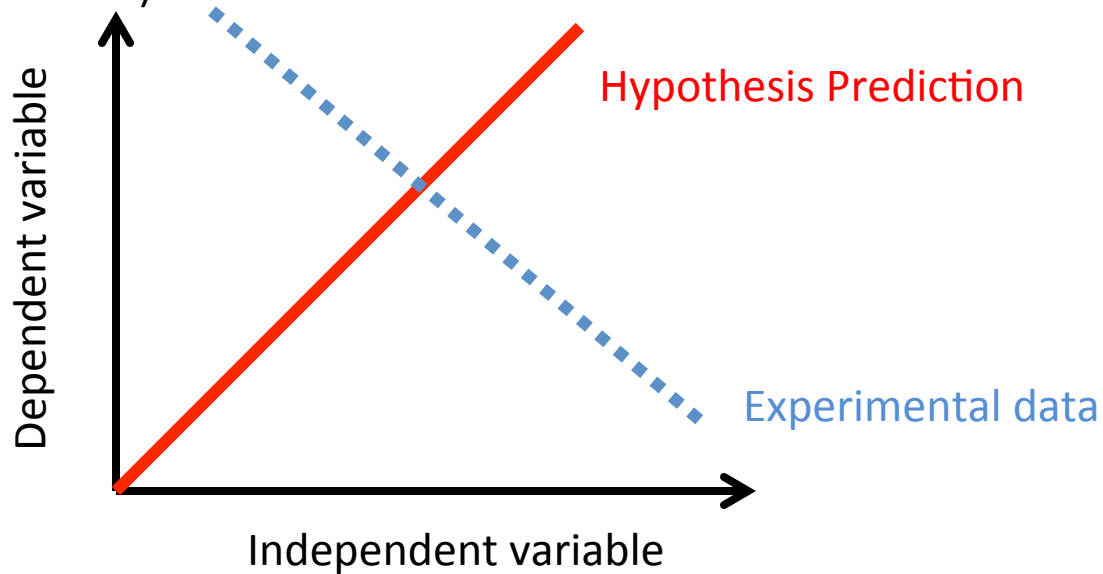
- (1) Your hypothesis must be based on previous observations from the literature or your laboratory. You should be very familiar with the previous work in the subject area of your hypothesis.
- (2) Your hypothesis must be testable in that there is some proposed analysis or experimentation that will produce data that can be quantitatively compared to the prediction of your hypothesis.
- (3) Your hypothesis must be non-trivial in that it cannot be explained by simple application of well known laws.

- (1) Your hypothesis must be based on previous observations from the literature or your laboratory. You should be very familiar with the previous work in the subject area of your hypothesis.
- Your hypothesis needs to be based on some observations or ideas, while at the same time it must be original.
 - You need to have a good familiarity with the literature related to your work. Your panel members may look at a literature search related to your proposal for a couple of hours before your presentation. You need to be aware of anything they may find. Don't let a cursory review of the literature by your panel 'show you up'.
 - You can use the literature to justify your hypothesis by showing there is an open question regarding a particular phenomenon, process, design, approach etc.

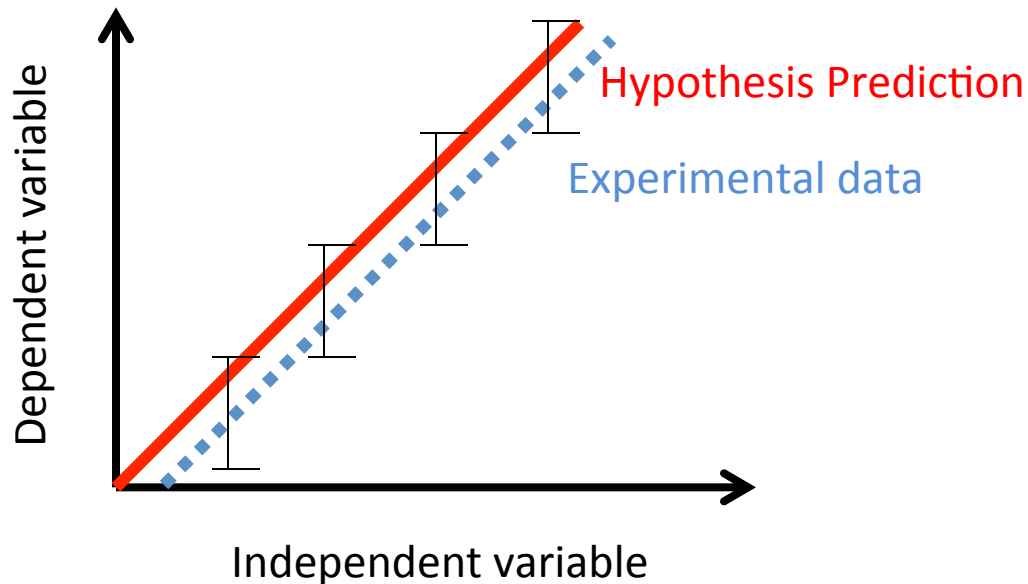
(2) Your hypothesis must be testable in that there is some analysis or experimentation that will produce data that can be quantitatively compared to the prediction of your hypothesis.

- The research that you propose should be focused on testing your hypothesis. The approach should be explained in a step by step, detailed manner. A superficial description that expects the panel to assume details of the experimental method, statistics of error and method of comparison with predictions of hypothesis may be deemed unsatisfactory.
- You may want to create an experimental design matrix which shows which independent variables will be varied and over what range, and what dependent variables you intend to measure. Be realistic about how many experiments are planned. Note that parameter space can be explored in numerical models as well as in the laboratory.
- If possible, a realistic assessment of error, sensitivity or statistical significance of experimental or numerical data is helpful.

(2) Your hypothesis must be testable in that there is some analysis or experimentation that will produce data that can be quantitatively compared to the prediction of your hypothesis. Example (but not the only way to test a hypothesis):



Hypothesis not true



Hypothesis true (within the error of the measurement). A statistical analysis of your experiment: hypothesis comparison is a good thing to propose (with details)

(3) Your hypothesis must be non-trivial in that it cannot be explained by simple application of well known laws.

Trivial Hypotheses:

The observed chemical transformation from A to B occurs because there is a negative free energy change.

The solidification occurs because the liquid is cooled below the melting temperature.

The yield stress of Al will increase when it is alloyed to make a solid solution