

Scientific Hypothesis Modeling

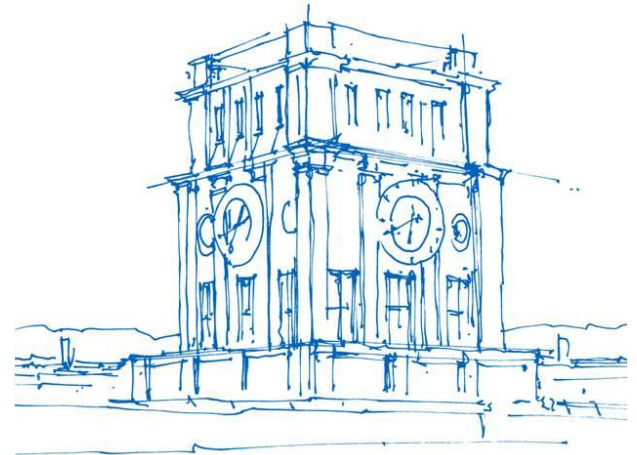
Jan Lauinger

Technical University of Munich

TUM Department of Electrical and Computer Engineering

Associate Professorship of Embedded Systems and Internet of Things

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Uhrenturm der TUM

Problem

- How to **formulate** a **title / topic** of a **paper / research internship / thesis**?
- How do you make sure the proposed **research** is **new**?
- Did the initially defined **title** change before the final **submission**?
- How can you **test / identify** new **evidence** against state-of-the-art research?
- How do you **quickly evaluate** a **topic proposal** of **external** students?

-> **Take scientific hypothesis modeling as help.**

Scientific Hypothesis

What is a hypothesis?

- Educated **guess / prediction / statement / phenomenon** that can be **tested** by a **research method / approach**.
- Tentative **answer** to **research question** which **has not** been **answered / tested**. Hypothesis **states** what your research **will** find.
- Not just a guess, the hypothesis must be based on existing theories and knowledge.

How to connect a new hypothesis to research?

- What **findings** does related work state?
- What **variables** or **combination** of variables **have / have not** been tested by state-of-the-art papers?
- Can you **improve / correct / disprove** an existing hypothesis?

Structure of a Hypothesis

How is a hypothesis constructed?

- Hypotheses propose a **relationship / trade-off** among **effect** and **cause** between **one** or **more variables**.

What is a relationship that we are interested in (if, then prediction)?

- **If** we change the research method at stage three, **then** our results will improve.
- **If** we add another layer of encryption, **then** the protocol will become secure in a new setting.
- **If** we use a proxy between clients and servers, **then** network delay increases but no MPC is required.

What are variables?

- **Dependent variables**: Something a researcher observes and measures. Also referred to as the assumed effect.
- **Independent variables**: Something a researcher changes or controls. Also referred to as the assumed cause.

Example Hypothesis

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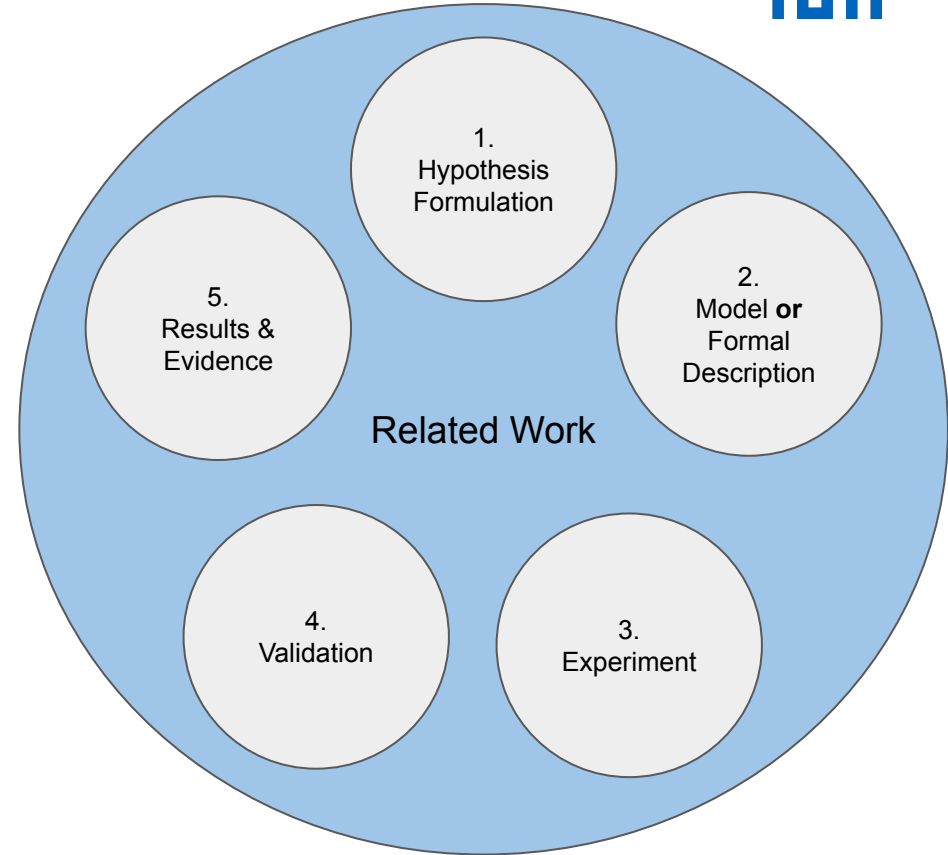
- Daily **exposure to the sun** leads to **increased levels of happiness**.
(independent variable, dependent variable, predicted relationship between variables, difference between groups)

Constructing a hypothesis

1. Research question: Do students who attend more lectures get better exam results?
2. State of the art: What are existing theories and studies? Based on what approach can I formulate a new educated assumption?
3. Preliminary hypothesis (expected to find): Attending more lectures leads to better exam results.
4. Refine hypothesis: Hypothesis must contain (1) variables, (2) predicted outcome of the experiment or analysis, and (3) scope of your study (e.g. specify group of students)
5. Example Hypotheses:
 - a. If a first-year student starts **attending more lectures**, then their **exam scores** will **improve**.
 - b. The **number of lectures attended** by first-year students has a **positive effect** on their **exam scores**.
 - c. **First-year students** who **attended most lectures** will have **better exam scores** than those who attended few lectures.

Hypothesis Testing

1. Define **variables, relationships, predictions**.
2. How to technically represent the relationship? What is your **approach / research method**?
3. What **tooling** is required to **conduct** the approach?
4. How to **plot / compare data** to get to a tentative answer / statement / prediction?
5. Does your evidence **support, contradict, or miss** the initially stated hypothesis? (intermediate results?)
6. **Stop or refine** hypothesis and **start over**.



Takeaways

Can you identify the **independent** and **dependent variables** in your research topics?

Can you define a **relationship of interest** among your variables?

Can you formulate a hypothesis on the **relationship**?

- What **findings** does related work state on the **relationship** and how did they approach their analysis?
- Can you **improve / correct / disprove** an existing **relationship**?
- Can you state a **new expected behavior** on a **relationship**?
- Can you make a **preliminary statement** based on your **initial results**?

Would you want to reflect your hypothesis in a paper title?

Further Things to Consider

Types of Hypothesis

- Simple hypothesis, Complex hypothesis, Empirical hypothesis, Null hypothesis, Alternative hypothesis, Statistical hypothesis, Logical hypothesis

Types of Phrasing

- **If/Then Phrasing:** If I eat more calories, **then** I will gain weight.
- **Correlation Phrasing:** The **more** calories that are eaten beyond the daily recommended requirements, the **greater** the weight gain will be.
- **Comparison Phrasing:** Those who eat more calories will gain **more** weight **than** those who eat fewer calories.

Checklist

- What tense is the hypothesis written in?
- Does the hypothesis contain both independent and dependent variables?
- Is the hypothesis framed using the if/then, correlation, or comparison framework (or sth similar)?
- Is the hypothesis worded clearly and concisely?
- Does the hypothesis make a prediction?
- Is the prediction specific?
- Is the hypothesis testable?

Best Practice

- Common to reject a Null Hypothesis rather than confirming other form of hypothesis (researchers might never know all influencing factors which exist in system model).