Empirical Research in Computer Science

Definitions

**RESEARCH:**
Diligent search or inquiry; scientific investigation and study to discover facts.

**SCIENCE:**
Systematic knowledge of natural or physical phenomena; Facts ascertained by observation, experiment, and introduction; Ordered arrangement of facts known under classes or heads; Theoretical knowledge as distinguished from practical; Knowledge of principle and rules of invention, construction, mechanism, etc., As distinguished from art.

**THEORY/MODEL:**
A system for explaining a set of phenomena by specifying constructs and the laws that relate these constructs to each other.

What Are The Available Research Paradigms?

<table>
<thead>
<tr>
<th>Fact:</th>
<th>information obtained through direct observation</th>
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<tbody>
<tr>
<td>Hypothesis:</td>
<td>educated guess, precedes an experiment</td>
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<tr>
<td>Experiment:</td>
<td>operation carried out (sometimes under controlled conditions) to discover unknown effect/law, test/establish hypothesis, illustrate a known law</td>
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<td>Theory:</td>
<td>possible explanation based upon many facts/reason</td>
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<tr>
<td>Law:</td>
<td>description/observation of behavior used for prediction based upon facts and reason</td>
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<tr>
<td>Model:</td>
<td>simplified representation of a system/phenomenon</td>
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<tr>
<td>Paradigm:</td>
<td>conceptual filter, how we perceive/interpret</td>
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<tr>
<td>Truth:</td>
<td>what really is</td>
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Research Approaches

**ESTABLISHED FIELD:**
- Easier to answer questions
- Areas better defined
- More consensus on the importance of an area
- Standard methods of study

**METHODOLOGICAL APPROACHES:**
**ANALYSIS:**
- Build a theory
- Derive properties
- Show boundary conditions and limits

**EXPERIMENTATION:**
- Formulate hypotheses
- Deduce empirical consequences
- Test the hypotheses by collecting data

Questions From Evaluating Research

**IS THERE NEW KNOWLEDGE?**
Were the methods used to obtain the knowledge scientifically sound?

**ARE THE RESULTS SIGNIFICANT?**
Do they improve our ability to describe, predict, control or explain?

**PICKING A TOPIC:**
- Build on prior theories
- Fill in gaps in theories
- Create new theories that explain better than old
- Disprove a commonly held “proven” theory

**CHARACTERISTICS:**
- Can be neatly packaged
- Focused
- Consistent methodology

Questions From Evaluating Research

**Develops new knowledge**
- which can be applied to the improvement of the field
e.g., software process or product

If in medicine:
- doctors were to lose their base of medical knowledge — they would have to stop working, e.g., surgeons couldn’t perform surgery without research-based knowledge about heart functions, anesthesia, meaning of symptoms, or the likely risk of a particular course of action.

What part of computer sciences is like this?

What would make the following dissertation research?
- Building a descriptive model/theory
- Building a predictive model/theory
- Improving an existing model/theory
- Verifying properties of a model/theory
- Implementing/automating a model/theory
Thinking About The Research Process
Theory And Research Perspectives

PROBLEM
STATEMENT/QUESTIONS

WHAT IS KNOWN
GAP IN KNOWLEDGE
RATIONALE/FUNDAMENTAL REASONS
SIGNIFICANCE/ASSUMPTIONS

Thinking About The Research Process
Procedural Perspective

SEARCH
QUESTIONS

POPULATION DATA NEEDED/VARIABLES
DATA SOURCE/INSTRUMENT
DATA COLLECTION PROCEDURE

Sample Experimental Dissertation
CHAPTER 1: Introduction:
A. General statement of the problem
B. Statement of the hypotheses, objectives, or questions
C. Definitions of terms (assumptions/limitations/significance)

CHAPTER 2: Review of the Literature:
A. Review of previous research
B. Pertinent opinion
C. Summary of the state-of-the-art (tie it all together)

CHAPTER 3: Method:
A. Description of the subjects (how chosen)
B. Research design and procedures
   (overview of statistical procedures)
C. Description of measures employed

Sample Experimental Dissertation
CHAPTER 4: Findings:
A. Description of finding pertinent to each hypothesis, objective, or question
B. Other findings

CHAPTER 5: Summary and Discussion:
A. Summary of research problem, method, and finding
B. Conclusions
C. Implications
D. Suggestions for further research