

Research Methodology & Validation: A Case Study

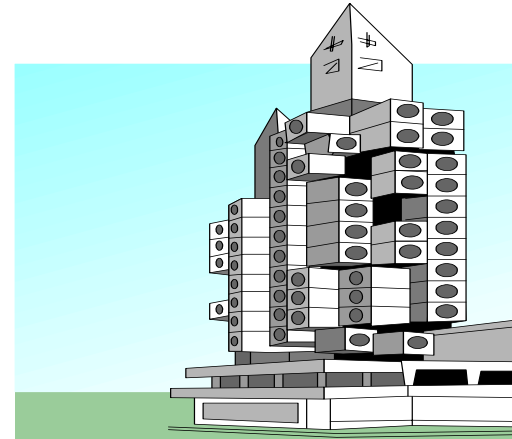
Professor Raymond E. Levitt

Dept. of Civil & Environmental Engineering;
Director, CRGP
Stanford University



Research Answers Questions!

- **Engineers** develop efficient **solutions to practical problems.**



- **Researchers** attempt to discover **valid answers to scientifically interesting questions!**





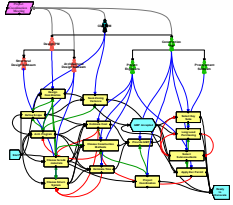
Identifying Good Research Questions. 1

- Motivation—Why would anyone care about the answer to your research question?
 - ▶ **Engineering Researchers** should:
 - seek to **ask and answer questions...**
 - through **well designed experiments...**
 - that **build on prior research...**
 - to **create new knowledge...**
 - to **enhance methods and tools**
 - that **engineers will use to develop solutions ...**
 - for **currently unsolved problems.**



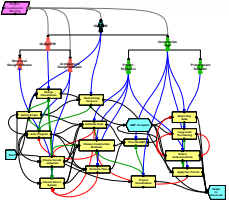
Identifying Good Research Questions. 2

- Try to identify **currently unsolved problems** in construction engineering & management practice
- Ask yourself what **currently unanswered questions**, if answered, could help to advance methods and tools for solving these **currently unsolved problems**



VDT Case Study—An Unsolved Problem

- Unsolved Problem (in 1985):
 - ▶ Fast-track design-build projects, intended to shrink time to completion of urgently needed facilities (such as semiconductor fabs) frequently encounter large cost and schedule overruns.
 - ▶ Managers, relying on their intuition, consistently underestimate the amount of extra coordination and rework effort in fast-track projects
 - ▶ Managers, using traditional project estimating and scheduling methods and tools, fail to predict these cost and schedule overruns



VDT Case Study—Research Questions

- Can we develop a simulation method and tool to predict the quantity and organizational locus of additional supervision, coordination and rework effort (the “hidden work”) in fast track projects?
 - ▶ What factors contribute to hidden work volume in fast-track projects?
 - ▶ Through what process do these factors interact to create hidden work?
 - ▶ Can we quantify the factors and their effects on project cost, schedule and process quality.
 - ▶ Can we embed these parameters in a simulation model of fast-track project organizations and their work processes
 - ▶ Can we validate the magnitude of the performance outcomes predicted by our simulation model
- Answers to these questions would enable managers to predict, and staff up for, the total work (direct + hidden work) in fast track projects, reducing unexpected delays, cost overruns & quality failures



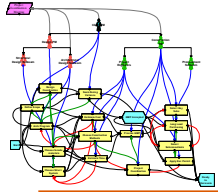
Designing Your Approach and Methodology

- Identify usable points of departure
 - ▶ You are almost never the first person to try and answer an interesting research question!!
 - *If you are, the question may not truly be very interesting!*
 - ▶ Use the results of your and others' prior research as a set of "stepping stones" to accelerate your progress
 - *Validated measurement scales and instruments that you could adopt to compare your results to prior work*
 - *Validated research apparatus from prior work*
 - *Findings about relevant variables*
 - *Prior attempts to describe a process that were not fully adequate or complete*
- Replication is a VIRTUE in science!

Stepping Stones of Science

- Science is a social process not a solo adventure!
- Your research is neither the first step nor the last step in answering a question—it is the “**next step**”!
- Use the stepping stones already in place from prior research to advance toward your research question.
- Aim to have your research be the “next stepping stone” for others to use on the path to answering your research question



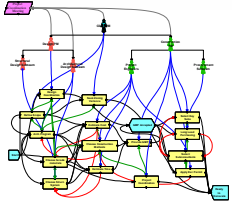


VDT Case Study—Points of Departure

- Information processing theories of organizations
 - ▶ Herbert Simon (Concept of “bounded rationality”)
 - ▶ Thompson (relating coordination effort to type of dependency)
 - ▶ Jay Galbraith (IP model of organizations; notion of “exceptions”)
 - ▶ Bennis (TREND – overlaying work process on organization)
- Simulation models of work processes and organizations
 - ▶ Physical Work
 - Paulson (Insight)
 - Halpin (Cyclone)
 - ▶ Knowledge Work
 - Cyert & March (Behavioral Theory of the Firm)
 - Cohen, March & Olson (Garbage Can Model)
 - Masuch & Lapotin (AAISS)

Approach and Methodology

- Your approach should lay out a series of “experiments” that can produce answers to your research questions. These could be:
 - ▶ Ethnographic studies (to identify relevant constructs)
 - ▶ Case studies (to form propositions out of constructs)
 - ▶ Surveys or questionnaires (to develop and test sets of hypotheses that form a theory)
 - ▶ Computational experiments (to test and refine theory)
 - “Intellective Experiments” (use idealized case input-data, test outcome predictions against predictions of theory)
 - “Emulation Experiments” (use real micro-data, test predictions against macro outcome data)

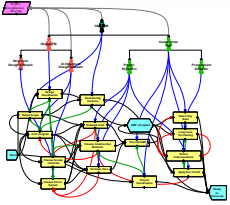


VDT Approach and Methodology

- We will develop a computational model of information flow in project teams, based on Jay Galbraith's information processing view of organizations, quantified by new ethnographic research.
- The simulation model will be an experimental platform to model and simulate project teams and the work processes they attempt to carry out.
- Model inputs will include: ...
- Model outputs will include: ...

Validating your Findings

- Experiments produce results that may be flawed in many ways, e.g.:
 - ▶ Flawed collection of input data
 - ▶ Incorrect modeling assumptions
 - ▶ Flawed measurement of output data
- Your proposed validation steps should ideally **triangulate several kinds of validation results against one another to increase your and others' confidence in your results**

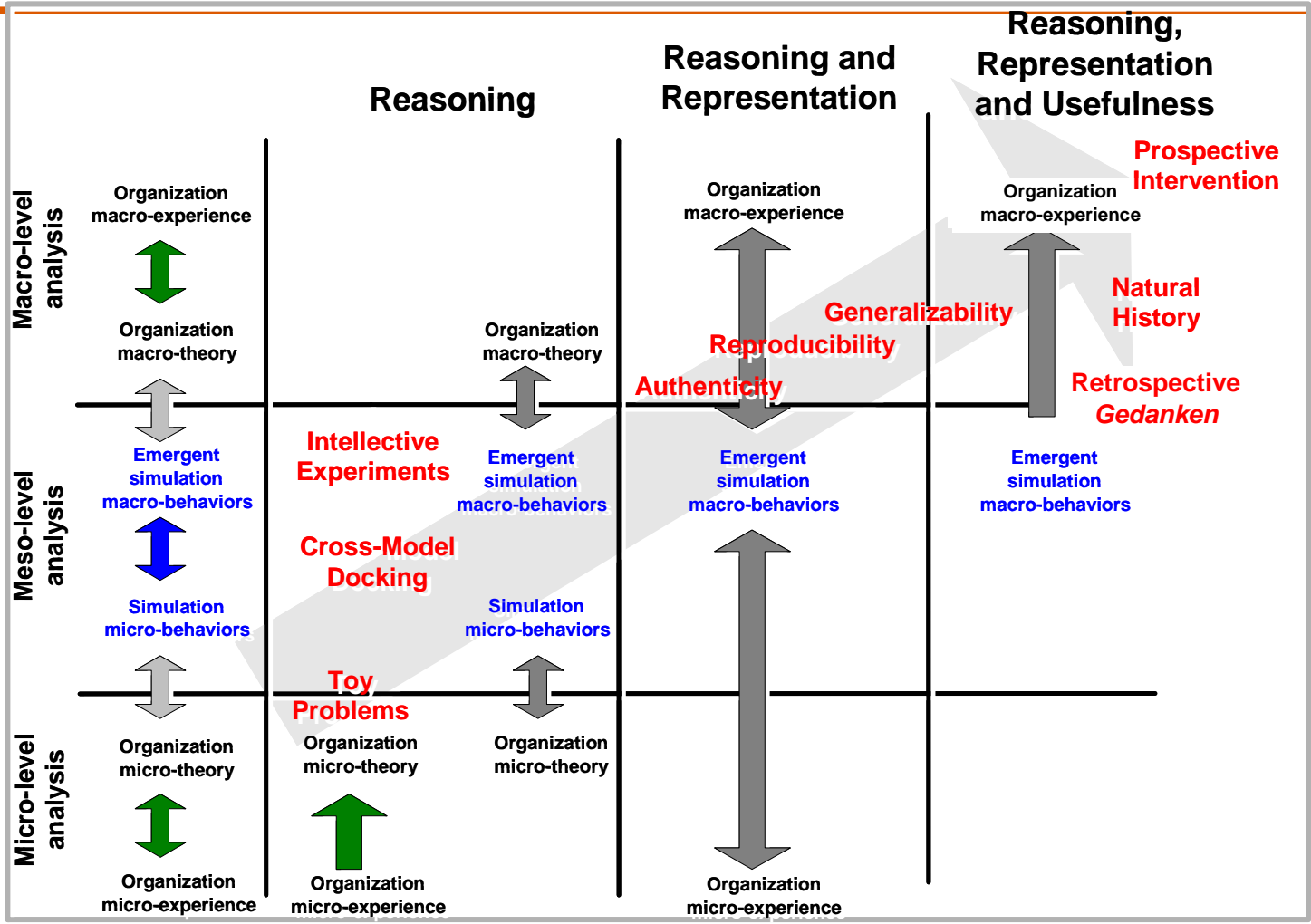


How VDT was Validated

1. We will **conduct a series of computational “virtual experiments,”** in which we vary work flow, task assignment, organizational structure... and compare the **model predictions** to **predictions of organizational contingency theory** to develop, test & refine a richer, quantitative theory of work flow in project teams.
2. We will conduct **retrospective field case studies** to calibrate, and **prospective field case studies** to validate, the **model’s predictions** against **real project outcomes**.
3. Once VDT has been calibrated and validated, the model can be used by managers to predict outcomes for real projects—i.e., it can serve as an analysis tool to help managers perform systematic project organization design.



Suggested Validation Trajectory for Computational Emulation Models of Organizations



Writing a Good Proposal

- Motivation
 - ▶ Unsolved problem/s that need better solutions
- Research Question/s (RQs)
 - ▶ If answered, they could help to solve problem/s
- Points of Departure
 - ▶ Distance from existing stepping stones to your question/s defines your contribution
- Approach and Methodology
 - ▶ How you will advance knowledge by traversing existing stepping stones to add the next stone
 - ▶ Clearly explain validation strategy
- Anticipated Risks and Mitigation Strategies
- Expected Contributions
 - ▶ **Intellectual:** Position your new stepping stone, relative to RQs, and to previous and subsequent stepping stones
 - ▶ **Practical:** How answers to your research questions can begin to address the unsolved problems
 - ▶ **Broader Impacts:** (Other speakers will discuss)

