Lessons Learned about Mixed Methods Research Strategies in Systems Engineering: Evidence from PhD Dissertations

Dr. Ricardo Valerdi, MIT
2ndLt. Kevin Liu, USMC, MIT
Dr. Jared Fortune, USC

8th Annual Conference on Systems Engineering Research
March 17-19, 2010 | Hoboken, New Jersey

© 2010 Massachusetts Institute of Technology
Takeaway

Systems engineering researchers should give more attention to **methods** and **methodology**...

...both when **planning** their research and when **presenting** their findings.
Outline

Which methods do Systems Engineering researchers choose?
Data from PhD dissertations

Positivist vs. Interpretivist Research
Examples from recent research

Observations for New Students
### Student Perspective

#### Methods

“a defined process for the acquisition and analysis of data” (Brown 2009)

#### Methodology

“overarching standpoint from which to view the problem and potential routes to a solution” (Brown 2009)

---

**Which methods should you pick?**
Literature – Research Methods

Controlled Settings
- Laboratory Experiments
- Experimental Simulations

Behavior Setting-Independent
- Judgment Tasks
- Sample Surveys
- Formal Theory

Natural Settings
- Field Experiments
- Field Studies
- Computer Simulations

No Observation of Behavior

Runkel and McGrath (1972)
Research on Human Behavior: A Systematic Guide
Data – Goals and Methods

Do current Systems Engineering researchers apply mixed methods?

Which methods do Systems Engineering researchers choose?
Data – PhD Dissertations

Total: 58

Academic Institutions Represented

USA
- MIT
- Stevens Institute of Technology
- USC
- George Washington University
- AFIT
- University of Newcastle
- Southern Methodist
- Stanford
- University of Texas at Arlington
- Univ of Washington
- University of Pennsylvania
- Vanderbilt University
- University of Minnesota
- Norwegian University of Science and Technology
- University of Groningen
- University of Twente
- SIKS
- Radboud University
- University of Amsterdam
- TU München
- University of Alberta

Norway
- Norwegian University of Science and Technology

Netherlands

Germany

Canada
Data – PhD Dissertations

62% of students applied mixed methods

- Field Studies
- Computer Simulations
- Sample Surveys
- Formal Theory
- Judgment Tasks
- Laboratory Experiments
- Field Experiments
- Experimental Simulations

n=58
Discussion – Methodology

- 10 theses (17.2%) lacked clear logic explaining the research approach.

- 22 theses (38%) showed a logical process linking different methods together, but lacked a cohesive argument for how data were linked to research questions.

- 26 theses (45%) documented a clear top-level architecture.

n=58
SE and Industry

Theory

Empirical Generalizations

Systems Engineering Theories

Predictions (Hypotheses)

Observations

Real World

Academic Innovation

Industry Innovation
## Discussion – Interpretivist vs. Positivist Research

<table>
<thead>
<tr>
<th>Construct Validity</th>
<th>Credibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positivist</strong></td>
<td><strong>Interpretivist</strong></td>
</tr>
<tr>
<td>Ask the right question</td>
<td>Does the participant buy it?</td>
</tr>
</tbody>
</table>

Adapted from Klein and Myers 1999 and Guba and Lincoln 1994
Discussion – Interpretivist vs. Positivist Research

**Positivist**

*Construct Validity*
Ask the right question

*Internal validity*
Cause and effect

**Interpretivist**

*Credibility*
Does the participant buy it?

*Confirmability*
Do others agree?

Adapted from Klein and Myers 1999 and Guba and Lincoln 1994
## Discussion – Interpretivist vs. Positivist Research

<table>
<thead>
<tr>
<th>Positivist</th>
<th>Interpretivist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construct Validity</strong>&lt;br&gt;Ask the right question</td>
<td><strong>Credibility</strong>&lt;br&gt;Does the participant buy it?</td>
</tr>
<tr>
<td><strong>Internal Validity</strong>&lt;br&gt;Cause and effect</td>
<td><strong>Confirmability</strong>&lt;br&gt;Do others agree?</td>
</tr>
<tr>
<td><strong>External Validity</strong>&lt;br&gt;Conclusions apply elsewhere</td>
<td><strong>Transferability</strong>&lt;br&gt;Conclusions useful elsewhere</td>
</tr>
</tbody>
</table>

Adapted from Klein and Myers 1999 and Guba and Lincoln 1994
Discussion – Interpretivist vs. Positivist Research

<table>
<thead>
<tr>
<th>Positivist</th>
<th>Interpretivist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construct Validity</strong></td>
<td><strong>Credibility</strong></td>
</tr>
<tr>
<td>Ask the right question</td>
<td>Does the participant buy it?</td>
</tr>
<tr>
<td><strong>Internal validity</strong></td>
<td><strong>Confirmability</strong></td>
</tr>
<tr>
<td>Cause and effect</td>
<td>Do others agree?</td>
</tr>
<tr>
<td><strong>External validity</strong></td>
<td><strong>Transferability</strong></td>
</tr>
<tr>
<td>Conclusions apply elsewhere</td>
<td>Conclusions useful elsewhere</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td><strong>Dependability</strong></td>
</tr>
<tr>
<td>Repeatable</td>
<td>Repeatable under change</td>
</tr>
</tbody>
</table>

Adapted from Klein and Myers 1999 and Guba and Lincoln 1994
Discussion – Interpretivist vs. Positivist Research

- **Positivist**
  - 44 of 58 (76%)
  - 11 of 58 (19%)

- **Interpretivist**
  - 3 of 58 (5%)

- **Both**
  - 11 of 58 (19%)

- **62% of students applied mixed methods**

- **n=58**
Experiences
Experiences
Observations for New Students

Recommendation #1
Part of the topic identification process should include the consideration of possible research methods and methodologies that would be relevant to research goals.
Observations for New Students

**Recommendation #1**
Part of the topic identification process should include the consideration of possible research techniques that would be relevant to research goals.

**Recommendation #2**
The topic of choice should address the needs of practitioners, and be achievable given the associated personnel, data, and time constraints.
Observations for New Students

Recommendation #1
Part of the topic identification process should include the consideration of possible research techniques that would be relevant to research goals.

Recommendation #2
The topic of choice should address the needs of practitioners, and be achievable given the associated personnel, data, and time constraints.

Recommendation #3
There should be sufficient flexibility in the definition of hypotheses to allow for changes given data availability, fidelity and quality.
Conclusion

Systems engineering researchers should give more attention to methods and methodology...

...both when planning their research and when presenting their findings.