In Quest for Requirements Engineering Oracles
Dependent Variables and Measurements for (good) RE

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Joint work with
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A regular case study in requirements engineering...

**Goal:** Test the sensitivity of a new RE method in company context
» Introduce a new RE method in project environment
» Conduct action research workshops following the new method
» Rate the method outcome according to assessment criteria defined using GQM

[Mendez Fernandez et al. A Case Study on the Application of an Artefact-Based Requirements Engineering Approach]
A regular case study in requirements engineering...

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 1: Ease of use</td>
<td>The approach is clear and understandable.</td>
</tr>
<tr>
<td>Sustainability</td>
<td>The approach and the taken decisions are reproducible.</td>
</tr>
<tr>
<td>Effectivity</td>
<td>All information and requirements are used in design and management activities.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>The approach supports a flexible process in response to individual project characteristics.</td>
</tr>
<tr>
<td>Productivity</td>
<td>The perceived productivity was high.</td>
</tr>
<tr>
<td>Structuredness</td>
<td>The RE process is systematic.</td>
</tr>
<tr>
<td>RQ 2: Syntactic Consistency</td>
<td>Elements in the specifications are used consistently.</td>
</tr>
<tr>
<td>Complexity</td>
<td>The complexity in the cross-references is low.</td>
</tr>
<tr>
<td>Syntactic Completeness</td>
<td>All syntactic elements needed to specify the requirements are given.</td>
</tr>
<tr>
<td>Syntactic Minimality</td>
<td>There are no unnecessary syntactic elements in the specifications.</td>
</tr>
<tr>
<td>Modularity</td>
<td>The specification is organised in modules, separated according to certain topics.</td>
</tr>
<tr>
<td>Traceability</td>
<td>Each requirement has a rationale.</td>
</tr>
<tr>
<td>Ease of Perception</td>
<td>The specifications are well-suited to be understood by people not involved into the process.</td>
</tr>
<tr>
<td>RQ 3: Unambiguity</td>
<td>The requirements are stated unambiguously.</td>
</tr>
<tr>
<td>Testability</td>
<td>The fulfillment of each requirement is measurable / testable.</td>
</tr>
<tr>
<td>Semantic Completeness</td>
<td>All stakeholder needs are reflected by the specifications.</td>
</tr>
<tr>
<td>Semantic Minimality</td>
<td>There are no needless requirements in the specifications.</td>
</tr>
<tr>
<td>Semantic Consistency</td>
<td>There are no contradictory statements in the specification.</td>
</tr>
</tbody>
</table>

What conclusions can I draw beyond the chosen context?

» How representative are the variables / how important are they to other contexts?
» How can the variables be efficiently measured?
» What relations exist between the variables?
Dependent variables in requirements engineering

**Why?**

Status quo in requirements engineering research
- Development of methods/tools for problems too often not properly understood
  » Control of validity / threat mitigation?

Research objectives
- Get a better understanding on RE phenomena, their dependencies and their measurability

**Our motivation**

*Understand RE phenomena and research implications on evidence-based RE research*
- Difficulties arising from cause-effect relationships
- Measurability and actionability
- Implications on threat to validity (e.g. possibilities of generalisation)
Study design

Research questions

RQ 1. Which RE-related phenomena exist, where in the project ecosystem do they manifest themselves, and how do they relate to each other?

RQ 2. Are the phenomena measurable?

RQ 3. Are the phenomena actionable?
Study design

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Study design

Requirements Engineering survey
NaPiRE www.re-survey.org
Globally distributed, replicated survey
on status quo and problems in RE

RE Phenomena inferred from open
questions on problems,
their causes and their effects

Research questions

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Research questions

RQ 1. Which RE-related phenomena exist, where in the project ecosystem do they manifest themselves, and how do they relate to each other?

RQ 2. Are the phenomena measurable?

RQ 3. Are the phenomena actionable?
Results

RQ 1: Dependent variables

- 93 variables with 167 dependencies

» Full result set: http://goo.gl/W3Altu
Results (Excerpt)

**RQ 1: Dependent variables**

"Implicit requirements not made explicit" \(\rightarrow\) "Incomplete requirements"
Results (Excerpt)

**RQ 1: Dependent variables**

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- "Incomplete requirements"
Results (Excerpt)

RQ 1: Dependent variables

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- "Incomplete requirements"
- "Increased effort in testing"
- "..."
Results (Excerpt)

RQ 1: Dependent variables

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...
**Results (Excerpt)**

**RQ 1: Dependent variables**

- Increased effort in testing
- Incomplete requirements
- Implicit requirements not made explicit
- Change requests
- Effort and time overrun
- Moving targets
Results (Excerpt)

RQ 1: Dependent variables

- “Implicit requirements not made explicit”
- “Incomplete requirements”
- “Increased effort in testing”
- “Effort and time overrun”
- “Change requests”
- “Failed acceptance”
- “Moving targets”
Results (Excerpt)

**RQ 1: Dependent variables**

- "Implicit requirements not made explicit"
- "Incomplete requirements"
- "Increased effort in testing"
- "Effort and time overrun"
- "Moving targets"
- "Change requests"
- "Failed acceptance"
- "Customer (dis-)satisfaction"
Results (Excerpt)

**RQ 2: Measurability**

- High degree of measurability for variables in RE dimension (59% of variables for RE)
- Unmeasurable variables comprise social phenomena (e.g., “Weak access customer needs”)
- Most measurable variables are measurable on basis of artefacts (e.g., “Underspecified requirements”)
- Decreasing understanding of variables and measurability the “farther away” from RE
Critical reflection

The good: Measurability in RE context

“Implicit requirements not made explicit”

“Customer (dis-)satisfaction”
Critical reflection

The good: Measurability in RE context

- High degree of measurability for RE-related variables
- Measurability (to a large extent) on basis of artefacts
  » Support of independent and comparable measurements
  » Already a better understanding of RE study context and its characteristics
Critical reflection

The bad: Limitations in RE context

- "Implicit requirements not made explicit"
- "Incomplete requirements"
- "Increased effort in testing"
- "Effort and time overrun"
- "Change requests"
- "Moving targets"
- "Failed acceptance"
- "Customer (dis-)satisfaction"
Critical reflection

The bad: Limitations in RE context

- Incomplete dependencies
  - Investigation was performed “inside-out” from RE and needs to be extended
Critical reflection

The bad: Limitations in RE context

- Incomplete dependencies
  » Investigation was performed “inside-out” from RE and needs to be extended
- Complex (yet incomplete) system of variables
  » Too many (especially unknown) variables intersect with each other
Critical reflection
The bad: Limitations in RE context

- Incomplete dependencies
  - Investigation was performed “inside-out” from RE and needs to be extended
- Complex (yet incomplete) system of variables
  - Too many (especially unknown) variables intersect with each other
- Even known variables strongly depend on subjectivity
  - Requirements engineering is also about beliefs, desires, experiences, expectations and politics
Critical reflection

The ugly: No RE oracle in sight!

- Incomplete dependencies
- Complex (yet incomplete) system of variables
- Even known variables strongly depend on subjectivity
Research implications (Excerpt)

General implications on evidence-based RE research

• No generalisation possible, but first set of variables and ideas for measurability
  » Aim for universal language rather than for universal truth
• High degree of subjectivity
  » Qualitative studies (e.g. expert judgment)
Research implications (Excerpt)

General implications on evidence-based RE research

• No generalisation possible, but first set of variables and ideas for measurability
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Implications on research on RE methodologies

• Inference of first improvement goals
  » Calibrate…
  – Study designs according to variables and their measurement
  – Variables if aiming for tackling “commonly accepted” problems
Threats to Validity

- Variables are incomplete (needless to say)
- Classification….
  - to some extent with a high disagreement
  - not the only possible way (and it’s positivistic)
- However: It is a way to learn more and we are confident to further continue it!
Future work

• Next replication of NaPiRE ongoing (www.re-survey.org)
  » Gather more RE phenomena
    • from NaPiRE
    • from other sources (e.g. via longitudinal studies)

Let’s build a big picture of RE variables together!

Full data disclosed to:
http://goo.gl/W3A1tu

• raw data
• full graphs
• R scripts
• …

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@mendezfe
A phenomenon is **measurable**, if its understanding is sufficiently mature such that

(i) an existing or anticipated measure, i.e., objective mapping to mathematical objects

(ii) can efficiently (e.g., in justifiable time) and effectively (i.e., preserving empirical observations) capture the phenomenon

(iii) under practical conditions and when applied on study objects which can be expected to be present in a software project ecosystem.

* Cohen’s Kappa values for classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>$P_o$</th>
<th>$2P_o - 1$</th>
<th>Cohen’s $\kappa$</th>
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<tbody>
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<td>0.60</td>
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<tr>
<td>Overall</td>
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<td>Company</td>
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<td>Measurability</td>
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