

Requirements Engineering Visualization: A Survey of the State-of-the-Art

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A decorative graphic at the top of the slide consists of two groups of circles. The left group has a solid light purple circle on the left and an empty light purple circle outline on the right. The right group has a solid light purple circle on the left, an empty light purple circle outline in the middle, and a solid light purple circle on the right. The word "Agenda" is written in black text, overlapping the solid circle in the left group.

Agenda

- Motivation
- Problem Context
- Methods
- Results
- Discussion
- Implications



The Problem

- What makes for effective visualizations during a particular requirements engineering phase ?
 - Is the visualization suitable for the task at hand?
 - What visualizations are complementary?
 - How can multiple perspectives of the problem domain synergistically influence decision making?
 - Where and when do visualization add value?



Motivation

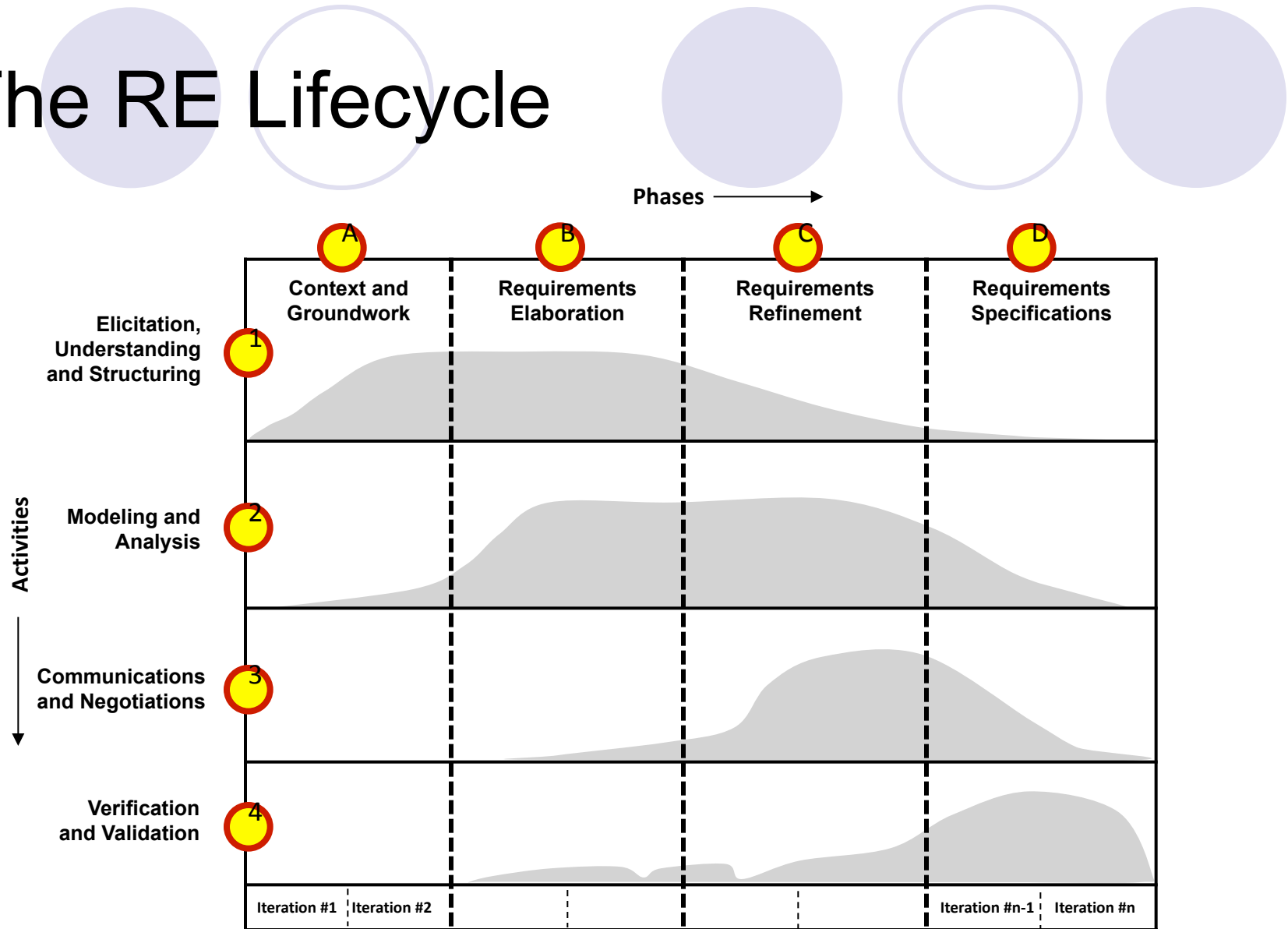
- We want to enable a constructive discussion about the coverage a requirements visualization with respect to the RE engineering activities
 - Discover gaps
 - Discover trends in the application of visualization in RE research and practice
 - Identify opportunities for further work in this area
- Our goal is to reflect on the fundamental problem of determining which visualization techniques fit which kind of phases and activities in a typical RE process

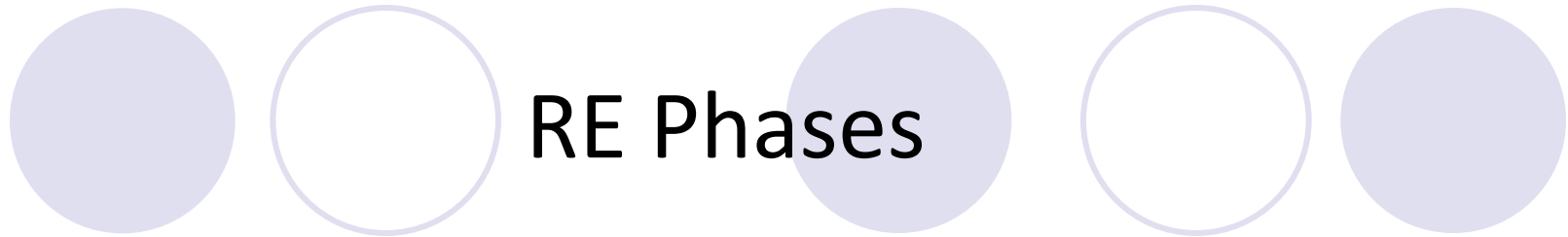


Our Approach

- We discuss and frame REV contributions within the scope of RE, by establishing a unified perspective of the RE lifecycle in terms of representative phases and activities
- **A RE-centric visualization perspective:**
 - Relate the visualizations to the *Phases* of progression of RE artifacts and the *Activities* that guide this progression

The RE Lifecycle





Context and Groundwork:

- Establish the business case; Scope the system; Mitigate serious risks; Establish process, methods, and techniques; Assess feasibility



Requirements Elaboration:

- Prepare initial system model; Document high-level organizational needs; Gather stakeholder needs and constraints



Requirements Refinement:

- Original artifacts are refined; Interactions among diverse artifacts are identified; Conflicts among requirements are resolved; Stakeholders agree on a set of requirements for the system



Requirements Specification, Management, and Evolution:

- Precise software specifications are produced from the artifacts; Ensure readability and traceability of requirements; Document change, or need for change is managed; Modifications to accommodate corrections, environmental changes, or new objectives



RE Activities

1

Elicitation, Understanding, and Structuring:

- Identify stakeholders and information sources; Identify system components and boundaries; Perform interviews, document review, other elicitation strategies; Structure requirements and RE activities

2

Modeling and Analysis:

- Construct artifacts for analysis by stakeholders and developers; Prepare initial models of the system, system interactions, use cases, scenarios, etc ; Use models and notation as drivers to prompt further elicitation

3

Communication and Negotiation:

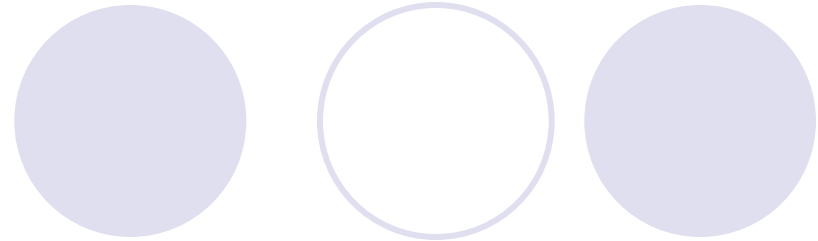
- Document, communicate requirements based on artifact analysis; Negotiate solutions to conflicts among requirements; Prepare precise specifications

4

Verification and Validation:

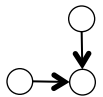
- Check artifacts for consistency and completeness; Ensure that requirements satisfy the intended real-world goals of the system

Visualization Types



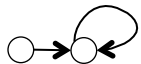
Tabular Visualizations

Typically made up of a series of intersecting columns and rows containing textual information.



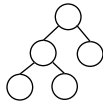
Relational Visualizations

Consist of a collection of nodes and connectors that indicate a relationship between components, but do not describe order of operation.



Sequential Visualizations

Similar to relational types, but intended to convey the order of operation between parts of the system or between the user and the system. { Flow Charts, State-Machine Diagrams }



Hierarchical Visualizations

Imply the decomposition of a system and its parts. { Goal-based Modeling Approaches }



Quantitative / Metaphorical Visualizations

Most commonly employed in the form of bar graphs, pie charts, or other figures conveying relative data. This type also includes more sophisticated techniques making use of visual clues such as size, shape, color, or line thickness in order to convey meaning at a glance.

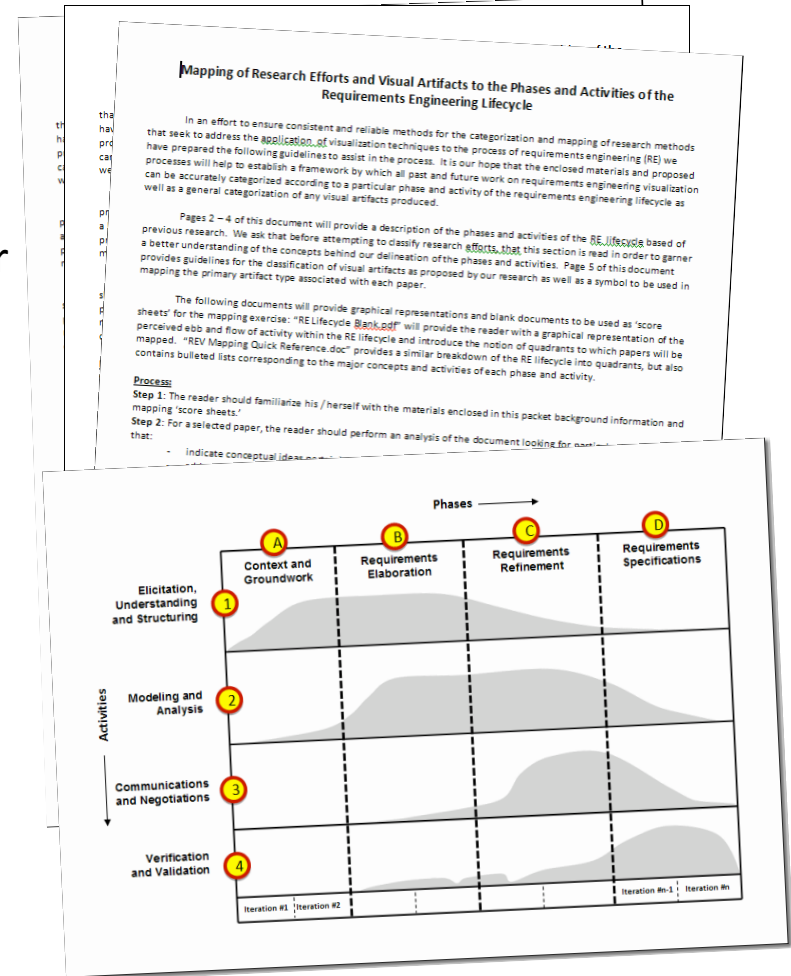
Scope of the Survey



- A total of 29 papers were reviewed from REV workshops held from 2006 to 2008.
- Among the 29 papers
 - 2 papers did not directly contribute to visualization artifacts during the RE process
 - 3 papers were not included as they did not apply directly to the RE process

Review Process

- Independent review by each of the four authors of this paper
 - Identify the appropriate phases and activities for the visualizations in each paper
 - 16 possible categories created by the overlapping phases and activities in the RE lifecycle model
 - Identify the visualization type, among the 5 possible ones, that was most notably influential in each research effort
- Aggregation of results:
 - Each mapping had to be agreed upon by at least two of the four reviewers to be included in the final result



Review Analysis and Artifacts

Sample Analysis

Line of Text	Phase	Activity
...we propose a methodology involving maximum <u>participation of stakeholders</u> where the <u>soft goals are elicited</u> in group sessions iteratively.	B	1
In this article we propose an agile visualization technique for <u>eliciting soft goals</u> by doing Agent Based Goal <u>Refinement</u> (ABGR) process repeatedly.	C	1
During the “Develop” sub-activity ABGR process is taken up to <u>elicit soft goals... for “Reviewing” by all stakeholders.</u>	B/C	1
During the last sub-activity all <u>stakeholders agree and “Adjust”</u> their own elicited goals...	C	3

- Analysis was typically performed through keyword searches and by careful reading in order to determine how the research goal applied to the sixteen corresponding categories and five visualization types.
- For one reviewer, it was determined that this paper was most relevant to phases B and C and activity 1. For brevity we refer to them as B1 and C1.

“A Visualization Technique for Agent Based Goal Refinement to Elicit Soft Goals in Goal Oriented Requirements Engineering.”

A.M. Sen and S.K. Jain, REV 2007.

Findings and Discussion

- 12 of the 29 papers were mapped to two categories while 3 of the 29 were mapped to three categories

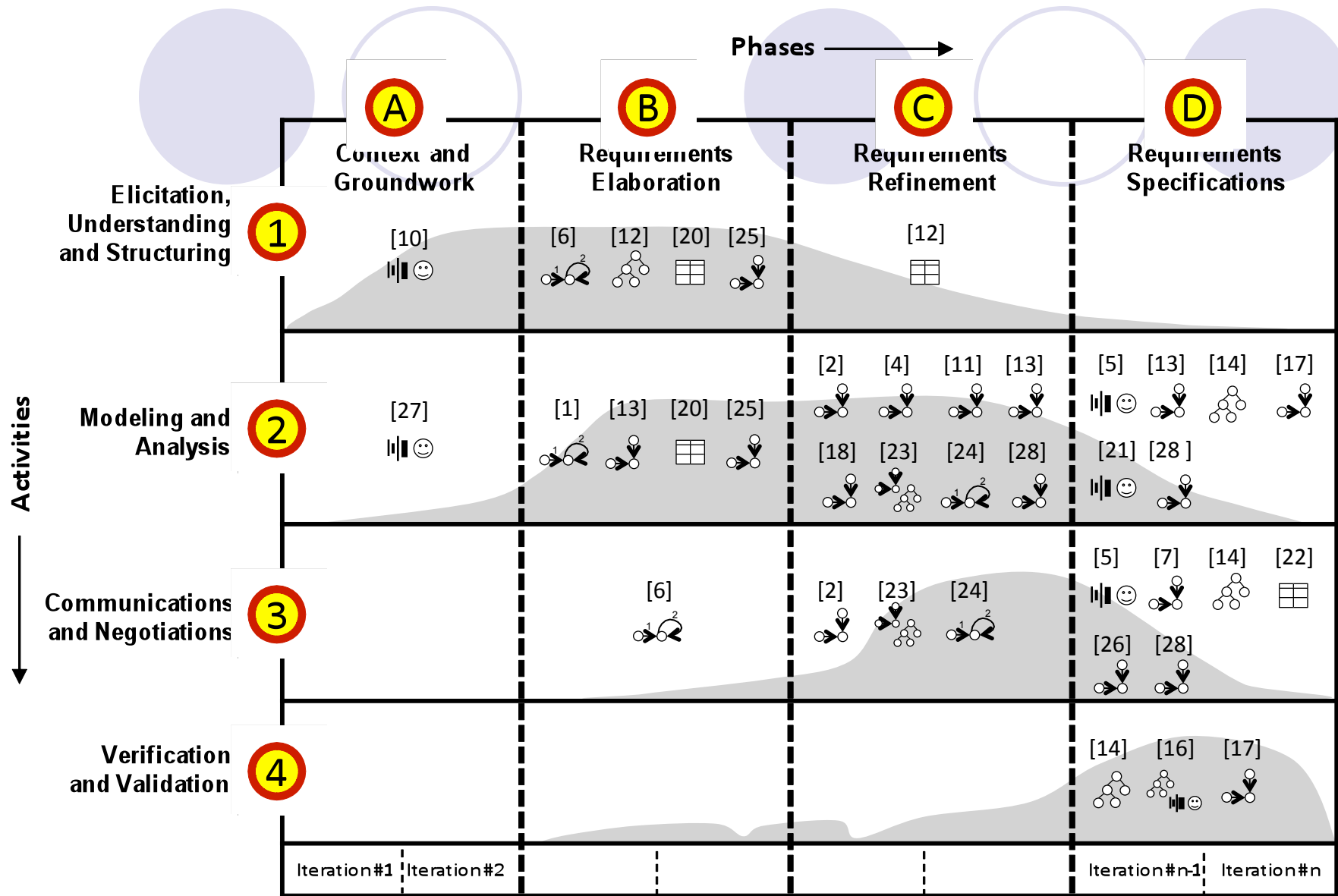
Mapping Consensus Among Reviewers

Consensus	12, 13, 20
3 Matches	2, 7, 14, 16, 23, 24, 25
2 Matches	1, 2, 4, 5, 6, 10, 11, 12, 13, 14, 17, 18, 20, 21, 22, 24, 26, 27, 28
No Matches	3, 8, 9, 15, 19, 29

	A	B	C	D
1	3 6 10 12 20 22 25 26 27	1 4 6 <u>12</u> 15 20 22 <u>25</u> 26	10 12 15 24	16
2	1 2 3 6 8 11 16 19 23 26 27	1 2 4 11 13 15 18 19 20 23 24 <u>25</u> 26	1 2 3 4 11 13 14 15 16 18 19 <u>23</u> <u>24</u> 28	3 4 5 13 14 17 18 21 28 29
3	8 9 10 16 22 27	6 7 18 26	<u>2</u> 10 14 15 17 <u>23</u> 24 27 28	4 5 <u>7</u> 9 11 14 16 17 18 19 21 22 25 26 27 28
4	9 10	26	2 26	1 3 5 9 10 11 <u>14</u> <u>16</u> 17 22 27 29

Key

- | | | | |
|---|--------------------|----------|------------------------------|
| 1 | 8 Pt, Normal, Grey | <u>3</u> | 12 Pt, Bold, Underline Black |
| 2 | 10 Pt, Bold, Black | 4 | 12 Pt, Bold, Underline, Red |



Hierarchical Visual

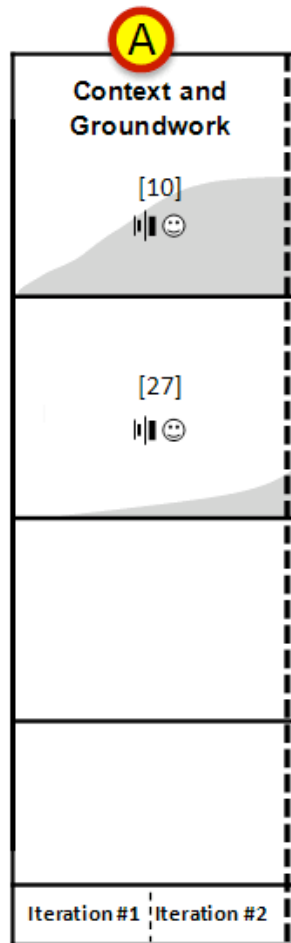
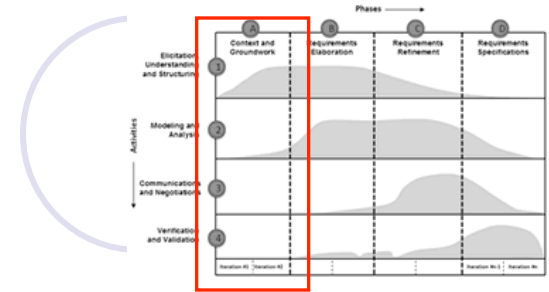
Sequential Visual

Quantitative/ Metaphorical Visual


Relational Visual

Tabular Visual


Findings and Discussion



- **Context and Groundwork:**
Establish the business case; Scope the system; Mitigate serious risks; Establish process, methods, and techniques; Assess feasibility
- 2 Mappings, each of the quantitative / metaphorical visualization type.
- Representative of a time when planning, feasibility, and decision-making are key activities.
- Least coverage of any phase.

 Hierarchical Visual

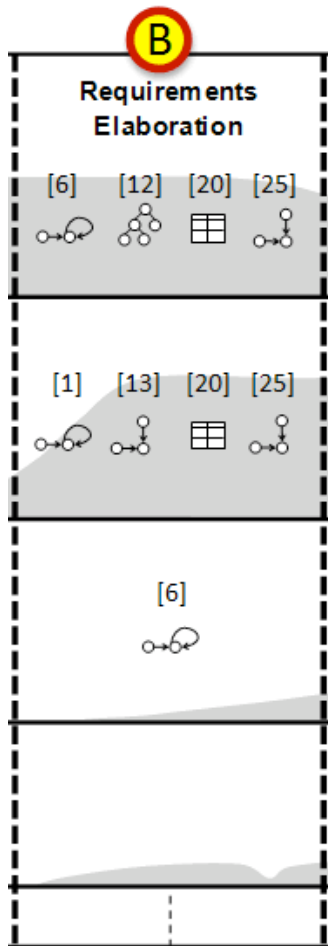
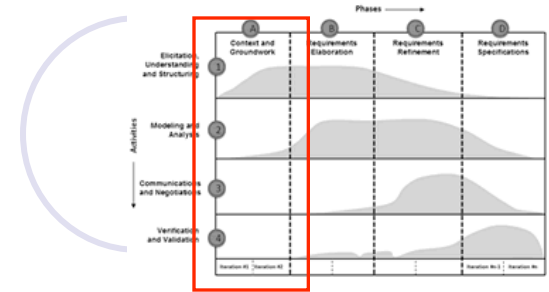
 Sequential Visual

 Quantitative/ Metaphorical Visual

 Relational Visual

 Tabular Visual

Findings and Discussion



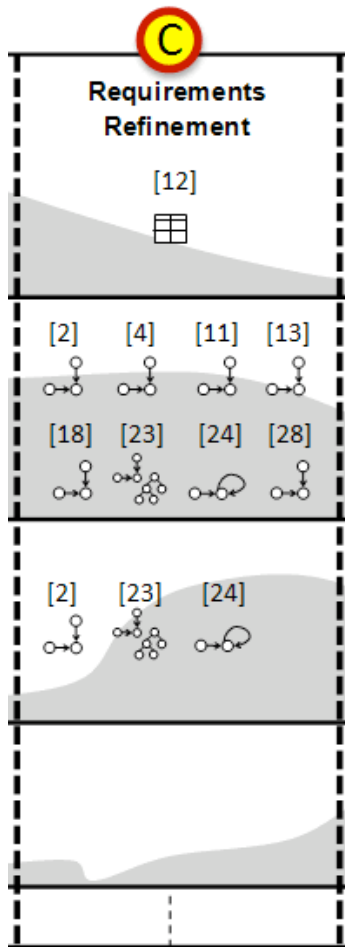
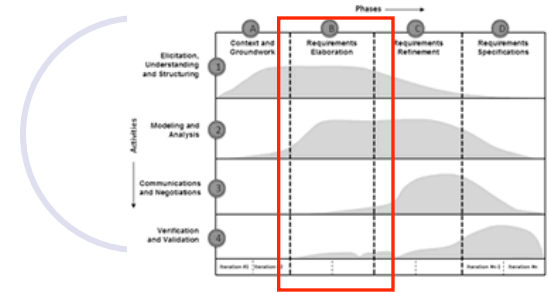
- **Requirements Elaboration**
Prepare initial system model; Document high-level organizational needs; Gather stakeholder needs and constraints
- Coverage of visualization type is notable.
2 Sequential, 2 Relational
1 Tabular, 1 Hierarchical
- During elicitation the use of diverse visualization types could help to maximize requirements discovery.

Hierarchical Visual
 Relational Visual

Sequential Visual
 Tabular Visual

Quantitative/ Metaphorical Visual

Findings and Discussion



- **Requirements Refinement**

Original artifacts are refined; Interactions among diverse artifacts are identified; Conflicts among requirements are resolved; Stakeholders agree on a set of requirements for the system

- 7 of the 9 mappings are of the relational visualization type.
- Although this seems appropriate, we are surprised by not seeing more sequential or hierarchical types as requirements are moving from elicitation to specification.

Hierarchical Visual

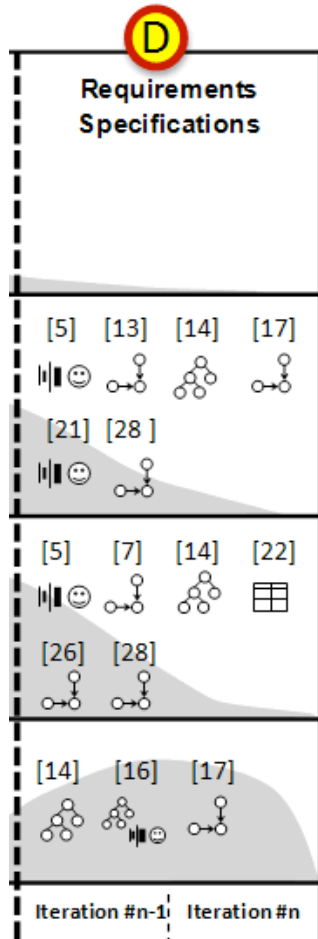
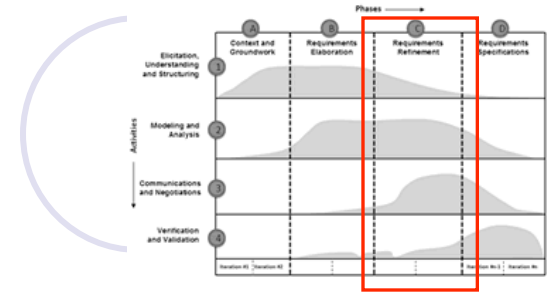
Sequential Visual

Quantitative/ Metaphorical Visual



Relational Visual



Tabular Visual

Findings and Discussion



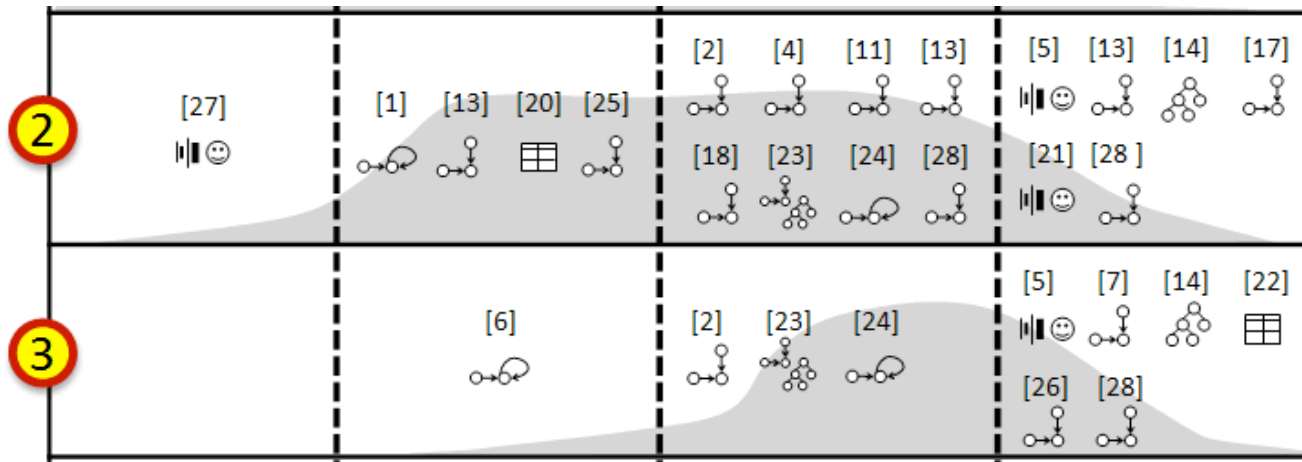
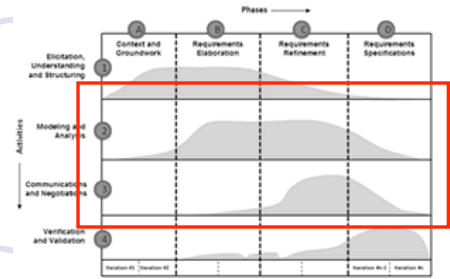
- **Requirements Specification**
Precise software specifications are produced from the artifacts; Ensure readability and traceability of requirements; Document change, or need for change is managed; Modifications to accommodate corrections, environmental changes, or new objectives
- Relational types are still the most prevalent; however, the increased usage of other types reflects a need to define system structure and organize requirements as to manage change and evolution.

 Hierarchical Visual
 Relational Visual



 Sequential Visual
 Tabular Visual



 Quantitative/ Metaphorical Visual

Findings and Discussion



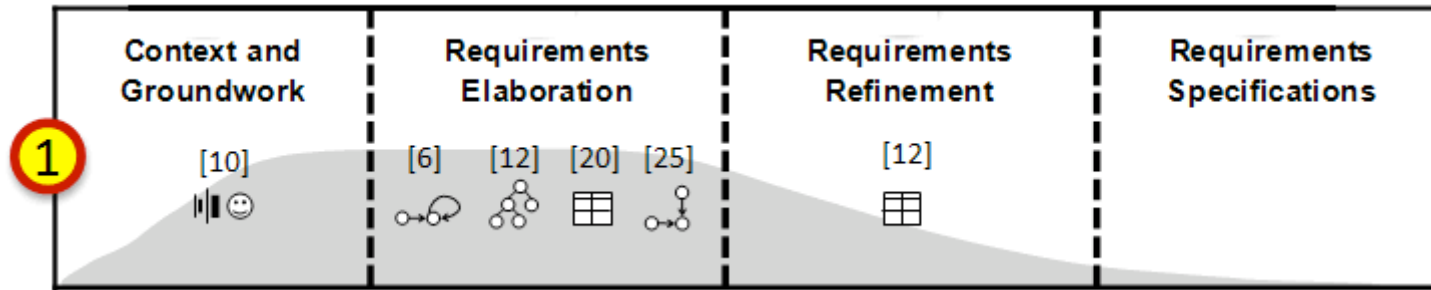
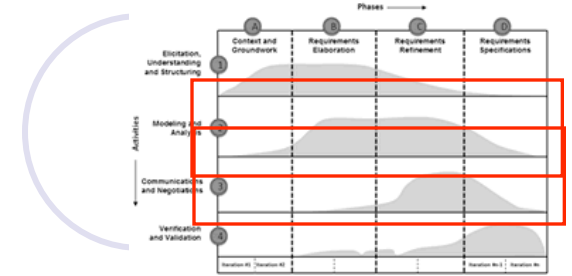
The large number of visualization efforts combined in these two rows are representative of what is almost certainly a typical bias in the view of how visualizations can best be used during RE, specifically in the areas of modeling and analysis.

 Hierarchical Visual
 Relational Visual

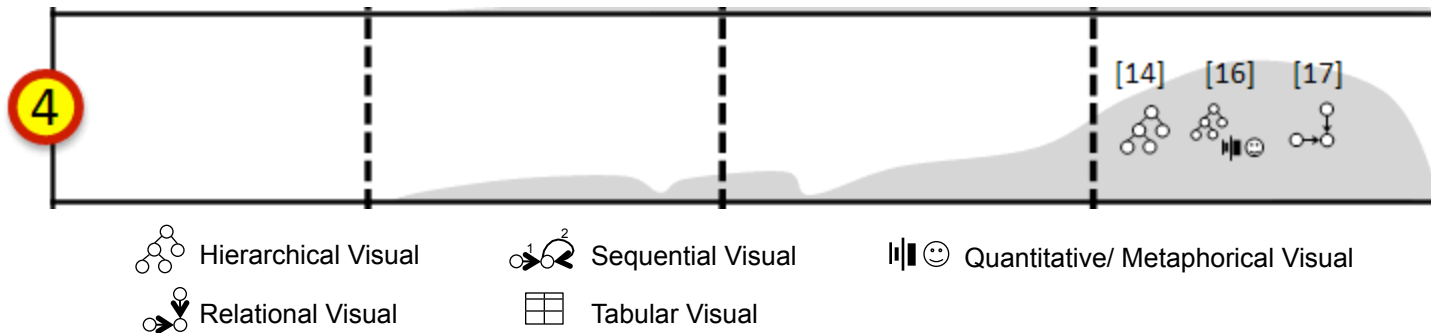
 Sequential Visual
 Tabular Visual



 Quantitative/ Metaphorical Visual



Findings and Discussion



In stark contrast, in rows 1 & 4 we see only three papers [10, 12, 16] that are unique to either of these rows. We believe that this represents an opportunity for future research to expand the roles of visualization in these areas, especially to support the activities of verification and validation.



 Hierarchical Visual
 Relational Visual

 Sequential Visual
 Tabular Visual

 Quantitative/ Metaphorical Visual

Findings and Discussion

Mappings By Year

	A	B	C	D
1	[10] 🔊 😊	[6] 🔗		
2		[1] 🔗	[2] [4] 🔗 🔗	[5] 🔊 😊
3		[6] 🔗	[2] 🔗	[5] [7] 🔊 😊 🔗
4				

2006

	A	B	C	D
1		[12] [20] 🔗 📊	[12] 📊	
2		[13] [20] 🔗 📊	[11] [13] 🔗 🔗	[13] [14] 🔗 🔗
3			[18] 🔗	[17] [21] 🔗 🔗
4				[14] 🔗

2007

	A	B	C	D
1		[25] 🔗		
2	[27] 🔊 😊	[25] 🔗	[23] [24] 🔗 🔗	[28] 🔗
3			[23] [24] 🔗 🔗	[22] [26] 📊 🔗
4				[28] 🔗

2008

21



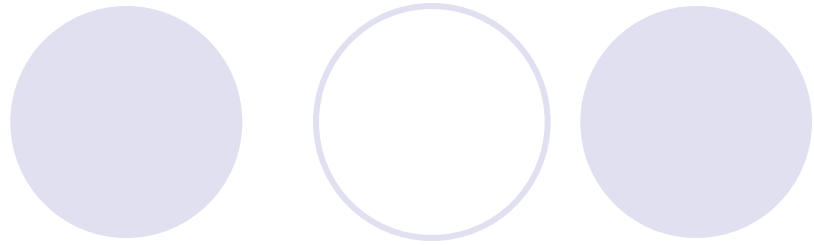
Conclusions

- Our research seeks to understand the use of visualization techniques in RE in current research and practice
- A initial effort in building an evaluation framework regarding the use of visualization
 - Still of great value to discuss and frame the various visualization types as they're applied to different problem contexts
 - Provides several insights into the characteristics of the visualization that make it most effective during RE



Future Work

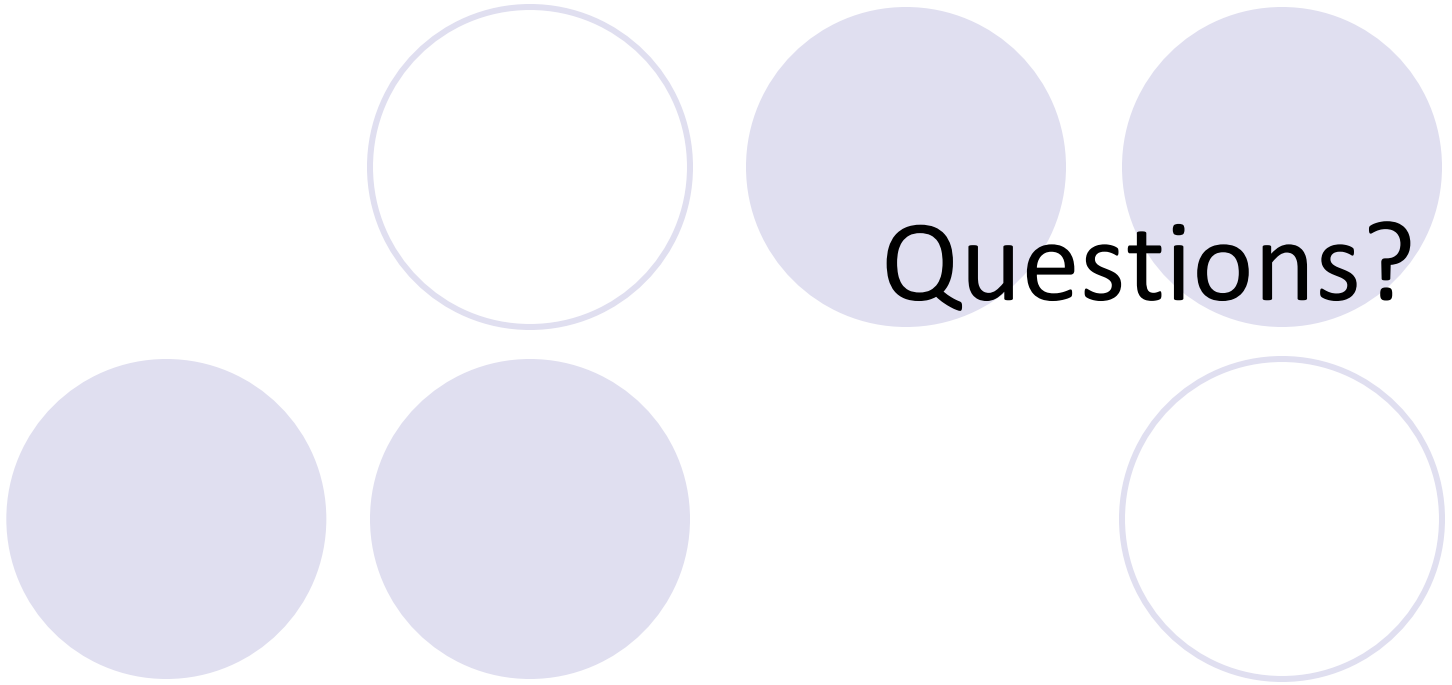
- Refinement of the classification systems relating to phases and activities of the RE lifecycle as well as the classifications of visualization types.

- 
- Ultimately, we hope that our work will lead to a system that will guide users in selecting visualization techniques according to the specific problem context of each RE phase and activity.

Acknowledgements



- We thank the anonymous reviewers whose valuable comments helped us improve this paper.
- We also thank all of the authors and researchers whose diligent efforts continue to contribute towards the advancement of the field of requirements engineering visualization.



Questions?