Usability of Requirements Techniques: A Systematic Literature Review

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A systematic literature review is…

> "…a form of secondary study that uses a well-defined methodology to identify, analyse and interpret all available evidence related to a **specific research question** in a way that is unbiased and (to a degree) repeatable"
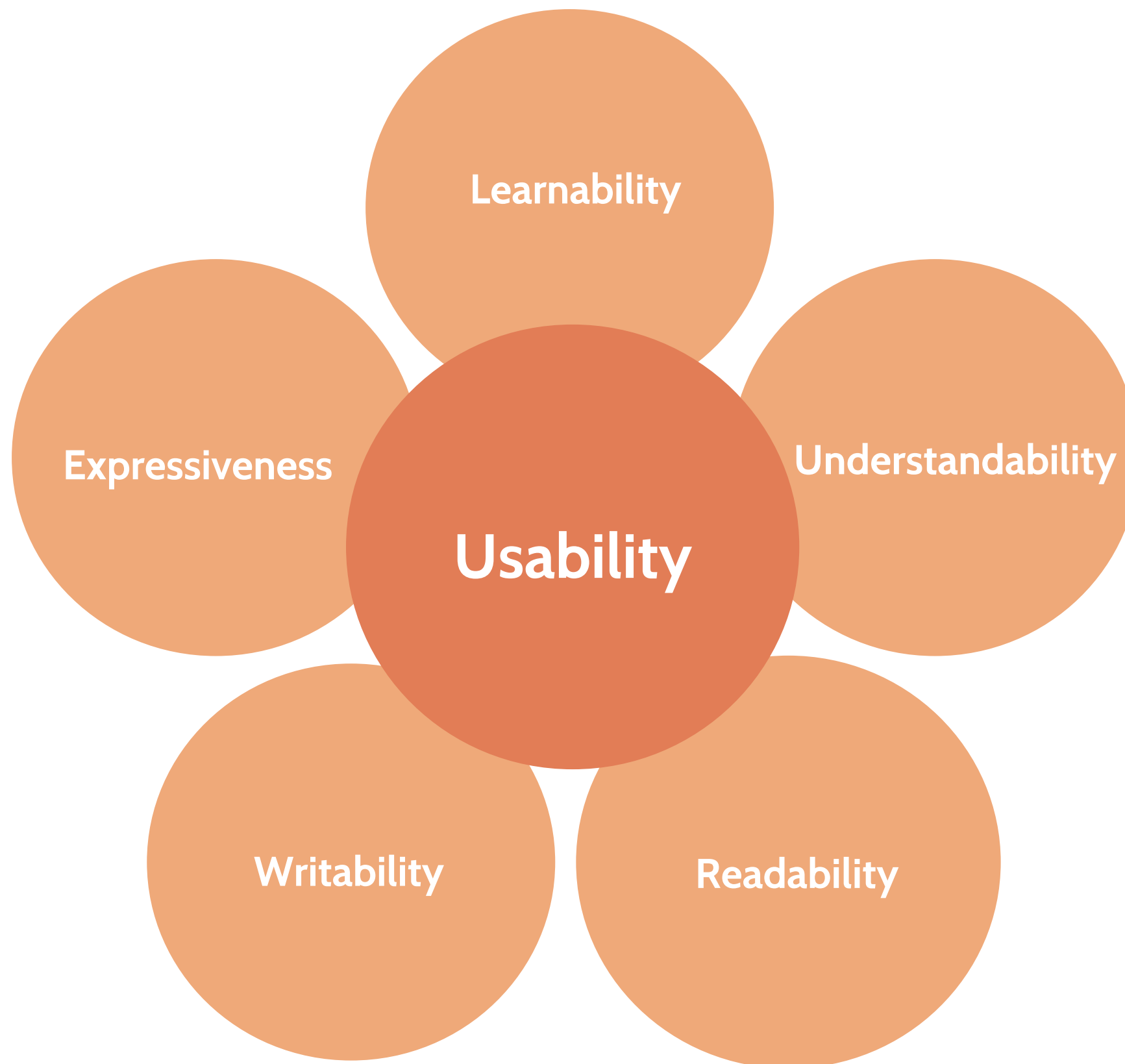
Barbara Kitchenham

Stuart Charters

How is the **usability** of requirements engineering **techniques** and **tools** addressed?

Search string

("requirements engineering" OR "requirements specification" OR "requirements model*" OR "requirements tool" OR "requirements process" OR "requirements analysis") AND usability AND (learnability OR understandability OR expressiveness OR readability OR writability OR "cognitive requirement*" OR "cognitive model*")

Search string

("requirements engineering" OR "requirements specification" OR "requirements model*" OR "requirements tool" OR "requirements process" OR "requirements analysis") AND usability AND (learnability OR understandability OR expressiveness OR readability OR writability OR "cognitive requirement*" OR "cognitive model*")

Notion of requirements engineering approaches

Search string

("requirements engineering" OR "requirements specification" OR "requirements model*" OR "requirements tool" OR "requirements process" OR "requirements analysis") AND **usability** AND (learnability OR understandability OR expressiveness OR readability OR writability OR "cognitive requirement*" OR "cognitive model*")

Usability *per se*

Search string

("requirements engineering" OR "requirements specification" OR "requirements model*" OR "requirements tool" OR "requirements process" OR "requirements analysis") AND usability AND **(learnability OR understandability OR expressiveness OR readability OR writability OR "cognitive requirement*" OR "cognitive model*")**

Quality attributes that compose usability

Inclusion criteria

Papers published in REJ

That answer the research question

Exclusion criteria

Secondary or tertiary studies

Papers that did not answer the research question

Papers with the same content in different versions

Data extraction strategy

Demographic data

- authors
- conference or journal
- year
- Google Scholar citations
- digital library
- approach
- baseline
- publication date
- primary study
- goal
- study type
- vested interest

Data extraction strategy

Demographic data	Usability approaches studied
• authors • conference or journal • year • Google Scholar citations • digital library • approach • baseline • publication date • primary study • goal • study type • vested interest	• usability attributes • main results of the usability evaluation • impact on the efficiency • impact on the effectiveness of the approach

Data extraction strategy

| Demographic data	Usability approaches studied	Usability evaluation
- authors - conference or journal - year - Google Scholar citations - digital library - approach - baseline - publication date - primary study - goal - study type - vested interest	- usability attributes - main results of the usability evaluation - impact on the efficiency - impact on the effectiveness of the approach	- evaluation method (process, control group, type of analysis, validity threats) - collected data (academic, industrial origins, participants number and background, which data was collected, raw data availability)

Primary studies selection

Total REJ
1996 - march 2015

427 → **search string** → 62 → **title & abstract** → 35 → **full paper** → 19
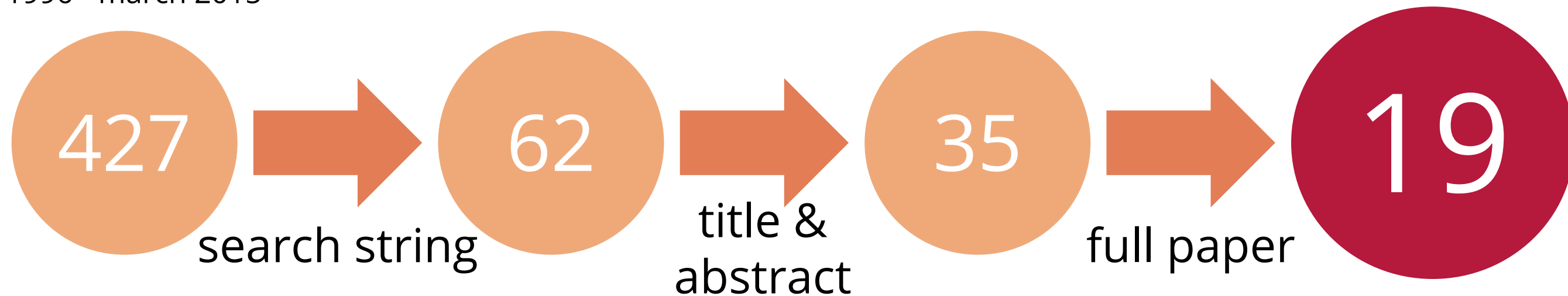
Demographic data

Analysing the demographic data

Approach	Study type					Vested interest
	Experiment	Quantitative assessment	Qualitative assessment	Expert opinion	Research paper	
AI		[9]	[9]		[9]	[9]
AWARE		[7]			[7]	[7]
ER	[6]	[30]	[30]			[30]
HSO		[4]			[4]	[4]
i*-based		[26]			[18]	[18]
NFR				[17]	[17]	[17]
OO-DFD	[12]	[12]				
Provotype				[10]	[10]	[10]
SCTL-MUS		[16]			[16]	[16]
SPL-based			[1]		[5]	[1] [5]
SPS			[28]		[28]	[28]
Text	[15]	[22]	[15]		[22]	[22]
Use cases	[12]	[12]			[29]	[29]
WebSpec		[24]			[24]	[24]
Z		[20]			[20]	

Covered RE approaches

Approach	Study type					Vested interest
	Experiment	**Quantitative assessment**	**Qualitative assessment**	**Expert opinion**	**Research paper**	
AI		[9]	[9]		[9]	[9]
AWARE		[7]			[7]	[7]
ER	[6]	[30]	[30]			[30]
HSO		[4]			[4]	[4]
***i**-based**		[26]			[18]	[18]
NFR				[17]	[17]	[17]
OO-DFD	[12]	[12]				
Provotype				[10]	[10]	[10]
SCTL-MUS		[16]			[16]	[16]
SPL-based			[1]		[5]	[1] [5]
SPS			[28]		[28]	[28]
Text	[15]	[22]	[15]		[22]	[22]
Use cases	[12]	[12]			[29]	[29]
WebSpec		[24]			[24]	[24]
Z		[20]			[20]	

Low number of papers involving UML

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AI		[9]	[9]		[9]	[9]
AWARE		[7]			[7]	[7]
ER	[6]	[30]	[30]			[30]
HSO		[4]			[4]	[4]
i*-based		[26]			[18]	[18]
NFR				[17]	[17]	[17]
OO-DFD	[12]	[12]				
Provotype				[10]	[10]	[10]
SCTL-MUS		[16]			[16]	[16]
SPL-based			[1]		[5]	[1] [5]
SPS			[28]		[28]	[28]
Text	[15]	[22]	[15]		[22]	[22]
Use cases	**[12]**	**[12]**			**[29]**	**[29]**
WebSpec		[24]			[24]	[24]
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i*-based		[26]			[18]	[18]
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SCTL-MUS		[16]			[16]	[16]
SPL-based			[1]		[5]	[1] [5]
SPS			[28]		[28]	[28]
Text	[15]	[22]	[15]		[22]	[22]
Use cases	[12]	[12]			[29]	[29]
WebSpec		[24]			[24]	[24]
Z		[20]			[20]	

2

≈16% of the papers are experiments

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	Experiment	**Quantitative assessment**	**Qualitative assessment**	**Expert opinion**	**Research paper**	
AI		[9]	[9]		[9]	[9]
AWARE		[7]			[7]	[7]
ER	[6]	[30]	[30]			[30]
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NFR				[17]	[17]	[17]
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SCTL-MUS		[16]			[16]	[16]
SPL-based			[1]		[5]	[1] [5]
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Text	[15]	[22]	[15]		[22]	[22]
Use cases	[12]	[12]			[29]	[29]
WebSpec		[24]			[24]	[24]
Z		[20]			[20]	

In 74% of the papers, authors are involved in the evaluated approach

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	Experiment	**Quantitative assessment**	**Qualitative assessment**	**Expert opinion**	**Research paper**	
AI		[9]	[9]		[9]	[9]
AWARE		[7]			[7]	[7]
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NFR				[17]	[17]	[17]
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SCTL-MUS		[16]			[16]	[16]
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Text	[15]	[22]	[15]		[22]	[22]
Use cases	[12]	[12]			[29]	[29]
WebSpec		[24]			[24]	[24]
Z		[20]			[20]	

26% of the papers were evaluated **independently**

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AI		[9]	[9]		[9]	**[9]**
AWARE		[7]			[7]	**[7]**
ER	[6]	[30]	[30]			**[30]**
HSO		[4]			[4]	**[4]**
i*-based		[26]			[18]	**[18]**
NFR				[17]	[17]	**[17]**
OO-DFD	[12]	[12]				
Provotype				[10]	[10]	**[10]**
SCTL-MUS		[16]			[16]	**[16]**
SPL-based			[1]		[5]	**[1] [5]**
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Text	[15]	[22]	[15]		[22]	**[22]**
Use cases	[12]	[12]			[29]	**[29]**
WebSpec		[24]			[24]	**[24]**
Z		[20]			[20]	

Usability approaches

Analysing the usability approaches

Approach	Usability attributes					
	Usability	**Understandability**	**Learnability**	**Readability**	**Writability**	**Expressiveness**
AI	[9]					
AWARE						[7]
ER		[30]	[6]	[6]		
HSO	[4]					
i*-based	[18]	[26]				
NFR	[17]	[17]				
OO-DFD		[12]				
Provotype	[10]	[10]		[10]	[10]	
SCTL-MUS	[16]	[16]				[16]
SPL-based	[5]					[1]
SPS		[28]				[28]
Text		[15] [22]			[22]	[15] [22]
Use cases		[29]	[29]			[29]
WebSpec				[24]		
Z	[20]		[20]			

Predominance of generic usability concepts

Approach	Usability attributes					
	Usability	Understandability	Learnability	Readability	Writability	Expressiveness
AI	[9]					
AWARE						[7]
ER		[30]	[6]	[6]		
HSO	[4]					
i*-based	[18]	[26]				
NFR	[17]	[17]				
OO-DFD		[12]				
Provotype	[10]	[10]		[10]	[10]	
SCTL-MUS	[16]	[16]				[16]
SPL-based	[5]					[1]
SPS		[28]				[28]
Text		[15] [22]			[22]	[15] [22]
Use cases		[29]	[29]			[29]
WebSpec				[24]		
Z	[20]		[20]			

Papers addressing more specific attributes are still in minority (≈21%)

Approach	Usability attributes					
	Usability	Understandability	Learnability	Readability	Writability	Expressiveness
AI	[9]					
AWARE						[7]
ER		[30]	[6]	**[6]**		
HSO	[4]					
i*-based	[18]	[26]				
NFR	[17]	[17]				
OO-DFD		[12]				
Provotype	[10]	[10]		**[10]**	**[10]**	
SCTL-MUS	[16]	[16]				[16]
SPL-based	[5]					[1]
SPS		[28]				[28]
Text		[15] [22]			**[22]**	[15] [22]
Use cases		[29]	[29			[29]
WebSpec				**[24]**		
Z	[20]		[20]			

≈60% of the approaches help improving usability

Approach	Usability attributes					
	Usability	**Understandability**	**Learnability**	**Readability**	**Writability**	**Expressiveness**
AI	**[9]**					
AWARE						**[7]**
ER		[30]	**[6]**	[6]		
HSO	[4]					
i*-based	**[18]**	**[26]**				
NFR	**[17]**	**[17]**				
OO-DFD		[12]				
Provotype	[10]	[10]		[10]	[10]	
SCTL-MUS	**[16]**	**[16]**				**[16]**
SPL-based	**[5]**					[1]
SPS		**[28]**				**[28]**
Text		~~[15]~~ **[22]**			**[22]**	~~[15]~~ **[22]**
Use cases		**[29]**	**[29]**			**[29]**
WebSpec				**[24]**		
Z	[20]		[20]			

≈10% of the approaches hurt usability

Approach	Usability attributes					
	Usability	**Understandability**	**Learnability**	**Readability**	**Writability**	**Expressiveness**
AI	[9]					
AWARE						[7]
ER		[30]	[6]	[6]		
HSO	[4]					
i*-based	[18]	[26]				
NFR	[17]	[17]				
OO-DFD		**[12]**				
Provotype	**[10]**	**[10]**		**[10]**	**[10]**	
SCTL-MUS	[16]	[16]				[16]
SPL-based	[5]					[1]
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≈20% of the results depend on the context in which the usability is evaluated

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	Usability	Understandability	Learnability	Readability	Writability	Expressiveness
AI	[9]					
AWARE						[7]
ER		[30]	[6]	**[6]**		
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SCTL-MUS	[16]	[16]				[16]
SPL-based	[5]					**[1]**
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Text		**[15]** [22]			[22]	**[15]** [22]
Use cases		[29]	[29]			[29]
WebSpec				[24]		
Z	**[20]**		**[20]**			

≈10% of the results are inconclusive

Approach	Usability attributes					
	Usability	Understandability	Learnability	Readability	Writability	Expressiveness
AI	[9]					
AWARE						[7]
ER		[30]	[6]	[6]		
HSO	[4]					
i-based	[18]	[26]				
NFR	[17]	[17]				
OO-DFD		[12]				
Provotype	[10]	[10]		[10]	[10]	
SCTL-MUS	[16]	[16]				[16]
SPL-based	[5]					[1]
SPS		[28]				[28]
Text		[15] [22]			[22]	[15] [22]
Use cases		[29]	[29]			[29]
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Usability evaluation

From the analysed papers…

53% provide a detailed description of the evaluation process

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37% use a control group to compare the approach with

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37% use a control group to compare the approach with

56% use some form of statistics (descriptive or tests)

74% of the evaluations use academic examples

32% make the raw data of their evaluation available

From the analysed papers...

53% provide a detailed description of the evaluation process

37% use a control group to compare the approach with

56% use some form of statistics (descriptive or tests)

74% of the evaluations use academic examples

32% make the raw data of their evaluation available

Evaluations using students (37%) are **slightly** more frequent

From the analysed papers…

53% provide a detailed description of the evaluation process

37% use a control group to compare the approach with

56% use some form of statistics (descriptive or tests)

74% of the evaluations use academic examples

32% make the raw data of their evaluation available

Evaluations using students (37%) are slightly more frequent

Evaluations involving students usually have a much higher number of participants (≈40)

Main findings

1

There are **relatively few** studies concerning usability of requirements approaches

We expect this kind of studies to become more abundant in a near future

Main findings

2

We found a **low number** of papers involving **UML**

This may be because UML notations have specific forums for publication

Main findings

3

There is a dominance of more **generic usability attributes** (e.g., understandability and usability)

The main results are typically about the **key advantages** of the approach and **open research challenges**

Main findings

4

Only a **minority** of the studies use a control group to compare the approach with some **baseline**

There is a positive tendency to make available the **raw data** of the analysis

Although **students** are used more frequently, the involvement of **practitioners** follows closely

Validity threats

Internal validity

Different keywords

Selection bias

Interpretation bias

Inter-rater agreement

Second reviewer cross-checking a sample of the papers

External validity

Only papers from REJ

REJ papers are typically written by RE experts

Are good representatives of RE mature work

Research Opportunities

Production of **independent** evaluations of RE approaches

→ enhance the perception of the maturity of the approaches

↓ potentially increases their acceptance by practitioners

Conclusions

There is relatively **little evidence** concerning the usability of the RE approaches

We found a **large variety of approaches** submitted to some form of usability assessment

We expect to find an increasing number of studies concerned with usability in the near future

The RE community is pushing for evaluations with **professional** practitioners, in **industrial** settings

Future work

Usability evaluation framework
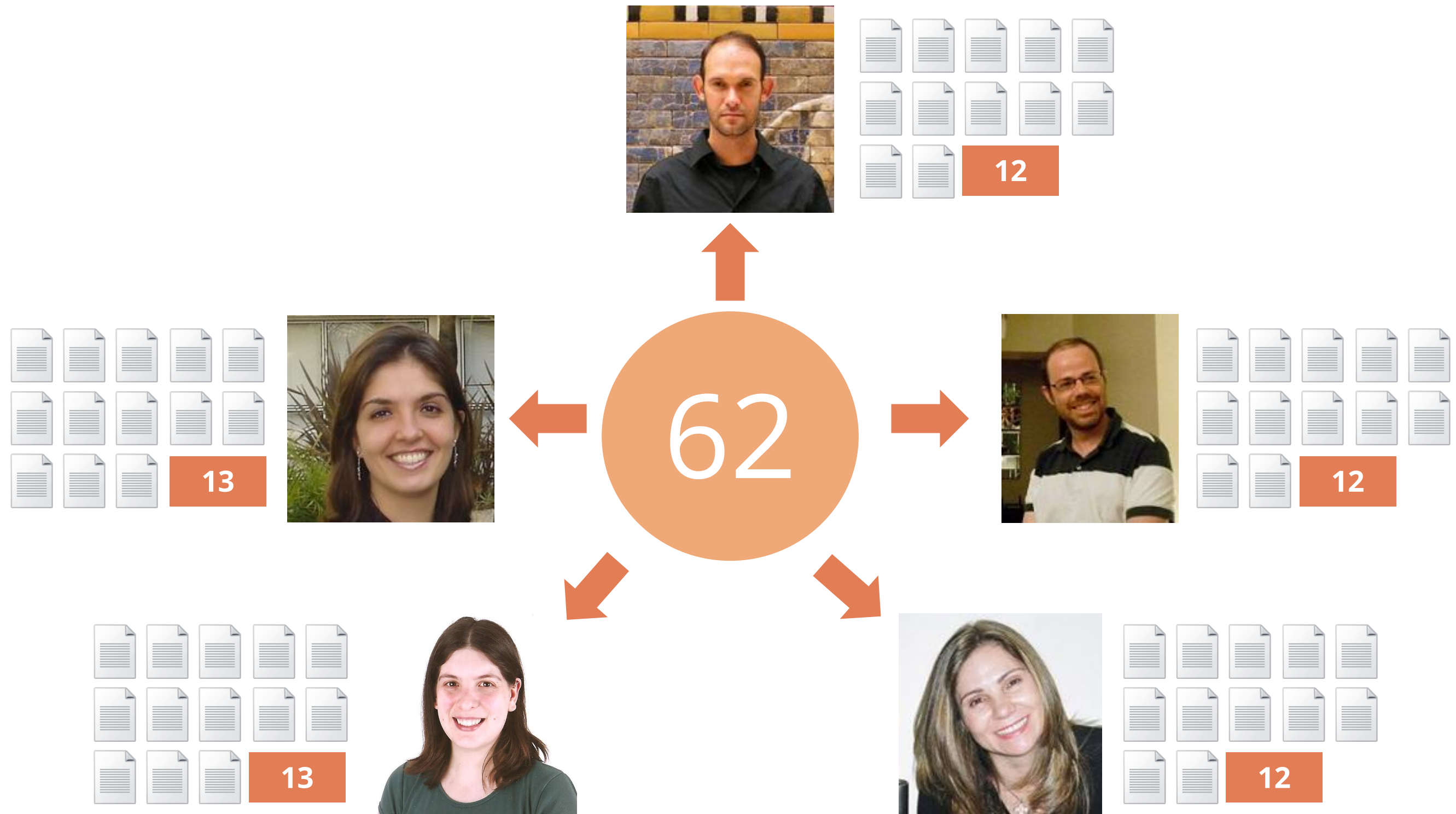
Open access repository

➤ For sharing resources and results

➤ Independent evaluation of RE approaches

Papers distribution

Papers 1st round: abstract

Papers distribution

Papers 2nd round: full paper

Papers 3rd round: double check