


A Systematic Literature Review on the Quality of UML Models

Marcela Genero, Ana M. Fernández, H. James Nelson, Geert Poels, Mario Piattini. (2011). A Systematic Literature Review on the Quality of UML Models. Journal of Database Management, 22(30), 46-70.




Introduction

- Introduction
- SLR Planning
 - Research questions
 - Search strategy
 - Search string
 - Inclusion criteria
 - Exclusion criteria
 - Clasification Scheme
- SLR Conducting
 - Chronology of activities
- SLR Reporting
 - Results
- Lessons Learned
- Conclusions

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2



Introduction

- Software = Complex → models
- Model Centric Development, Model Driven Development
- “Should we do modeling?” → “How should we do modeling?”
- Code quality → models quality
- UML = “standard” modeling language
- UML model quality is becoming relevant

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Introduction

Main goal-> Present a **SLR** for investigating the **state of the art on UML model quality**, by locating, evaluating, and interpreting relevant research to date that is related to UML model quality.

First report (1997- Sep 2007)

Final report, extended till Dec 2009

<http://alarcos.esi.uclm.es/SLRTool>

A Systematic Literature Review on the Quality of UML Models 4




Planning: Research questions

- **RQ1:** Which type of UML model quality has been investigated by researchers?
- **RQ2:** Which research methods are used in research on UML model quality?
- **RQ3:** What is the nature of the research results on UML model quality?
- **RQ4:** Which research goals are aimed at in research on UML model quality?
- **RQ5:** Which type of UML diagrams is the focus of the research on UML model quality?

5

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Planning: Search strategy

- Electronic collections → computer science and management information systems journals
 - SCOPUS database
 - Science@Direct (Computer Science)
 - Wiley InterScience
 - IEEE Digital Library
 - ACM Digital Library
 - SPRINGER database
- Type of documents
 - Journals
 - Conferences
 - workshops

6

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Planning: Search string

Major terms	Alternative terms
Quality	quality OR consistency OR maintainability OR understandability OR completeness OR comprehension OR comprehensibility OR testability OR defect OR effectiveness OR complexity OR readability OR metric OR measure OR efficiency OR validation OR verification OR layout
UML	UML OR Unified Modeling Language
Representation	Representation OR diagram OR model

7

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↓

(UML OR UNIFIED MODELING LANGUAGE) AND (REPRESENTATION OR DIAGRAM OR MODEL) AND (QUALITY OR CONSISTENCY OR MAINTAINABILITY OR UNDERSTANDABILITY OR COMPLETENESS OR COMPREHENSION OR COMPREHENSABILITY OR TESTABILITY OR DEFECT OR EFFECTIVENNES OR COMPLEXITY OR READABILITY OR EFFICIENCY OR VALIDATION OR VERIFICATION OR LAYOUT)

8

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ClarcoS

Planning: Inclusion criteria

- Papers included if:
 - dealt with UML and the tangible results of the modelling process
 - were written in English
 - were published between 1997 and 2009

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9




ClarcoS

Planning: Exclusion criteria

- The following papers were excluded:
 - pure discussion and opinion papers
 - abstracts or PowerPoint presentations
 - duplicates
 - research focusing issues other than UML model quality
 - where quality is mentioned only as a general introductory term in the paper's abstract
 - Papers were also excluded if they dealt with the quality and complexity of UML as a language
 - summary of a workshop

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10



Planning: Classification scheme

- Type of quality (RQ1)
 - Syntactic**
 - Correctness
 - Semantic**
 - Consistency
 - Completeness
 - Correctness
 - Pragmatic**
 - Maintainability
 - Analyzability
 - Understandability
 - Testability
 - Functionality
 - Executability
 - Reusability
 - Complexity
 - Dependability


***Syntactic quality** refers to how well the model adheres to the rules of the language.*

***Semantic quality** refers to how faithfully the modeled system is represented. There are two semantic goals: validity and completeness.*

***Pragmatic quality** refers to how well the model is understood. In a more general sense, pragmatics refers to the use that is made of something.*

11

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Planning: Classification scheme

- Type of evidence (RQ2)
 - Non empirical**
 - Speculation
 - Example
 - Literature review
 - Empirical**
 - Experiment
 - Case study
 - Survey

12


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Planning: Classification scheme

- Type of results (RQ3)
 - quality model
 - notation
 - method, technique, methodology, process, approach, strategy or algorithm
 - tool
 - metric
 - knowledge
 - pattern
 - view
 - checklist, guideline, rule or modeling convention

A Systematic Literature Review on the Quality of UML Models 13




Planning: Classification scheme

- Research goal (RQ4)
 - Research into **understanding** quality seeks to define the various dimensions of quality. This research also aims at understanding the factors that impact UML model quality.*
 - Measuring** quality is concerned with developing and evaluating scales that can be used to characterise (qualitatively or quantitatively) UML model quality.*
 - Research that **evaluates** quality investigates the relationship between quality measurements and real-world experiences with the UML model. The goal is to attach a value judgement to quality measurements.*
 - Quality **assurance** research examines how to ensure that the process that produces the UML model actually does produce a high-quality UML model.*
 - The research into **improving** quality examines how to increase the current quality of UML models.*

- understanding
- Measuring
- evaluating
- assuring
- improving

A Systematic Literature Review on the Quality of UML Models 14




Planning: Classification scheme

- Type of Diagram (RQ5)
 - Structure diagrams**
 - class diagram
 - component diagram
 - object diagram
 - composite structure diagram (UML 2.0)
 - deployment diagram
 - and package diagram
 - Behavior diagrams**
 - activity diagram
 - use case diagram
 - state diagrams
 - Interaction diagrams**
 - sequence diagram
 - communication diagram
 - time diagrams
 - light interaction diagram (UML 2.0)

15

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Planning: Chronology of activities

Time	Planning	Conducting	Reporting	Outcomes
First phase				
July 2007	Protocol development			Review protocol.
Sept 2007		Data retrieval (until Sep 2007)		Form with the general information of the papers. (1500 papers) .
		Study selection upon abstracts and titles		Form with the general information of the selected papers (483 papers) .
Mar2008		Retrieval of the files of the primary studies		Repository of papers (483 papers) .
Apr 2008		Remove duplicates		Form with the general information of the papers (399 papers) .
Jul 2008	Protocol improvement	Pilot data extraction		Data extraction form with the classification scheme refined.
Aug 2008		Study selection and Data extraction upon the full text		Data extraction form completed with the classification of 215 primary studies.
Feb 2009		Resolution of doubts in classification of primary studies in group		Revisited data extraction form with classification of the primary studies (193) .
Mar 2009		Data synthesis		
July 2009			Pilot report	

16

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Planning: Chronology of activities

Time	Planning	Conducting	Reporting	Outcomes
Second phase				
Mar 2010		Update of searches Data retrieval (until Dec 2009)		Form with the general information of the papers (979).
Mar 2010		Study selection upon abstracts and titles		Form with the general information of the selected papers (140).
		Retrieval of the files of the primary studies		Repository of papers 140).
		Remove duplicates		Form with the general information of the papers (103).
Feb 2010		Study selection and Data extraction upon the full text		Data extraction form completed with the classification of primary studies (103)
March 2010		Resolution of doubts in classification of primary studies in group		Revisited data extraction with the classification of primary studies (73)
Apr 2010		Data synthesis		
Jul2010			Final report	

17

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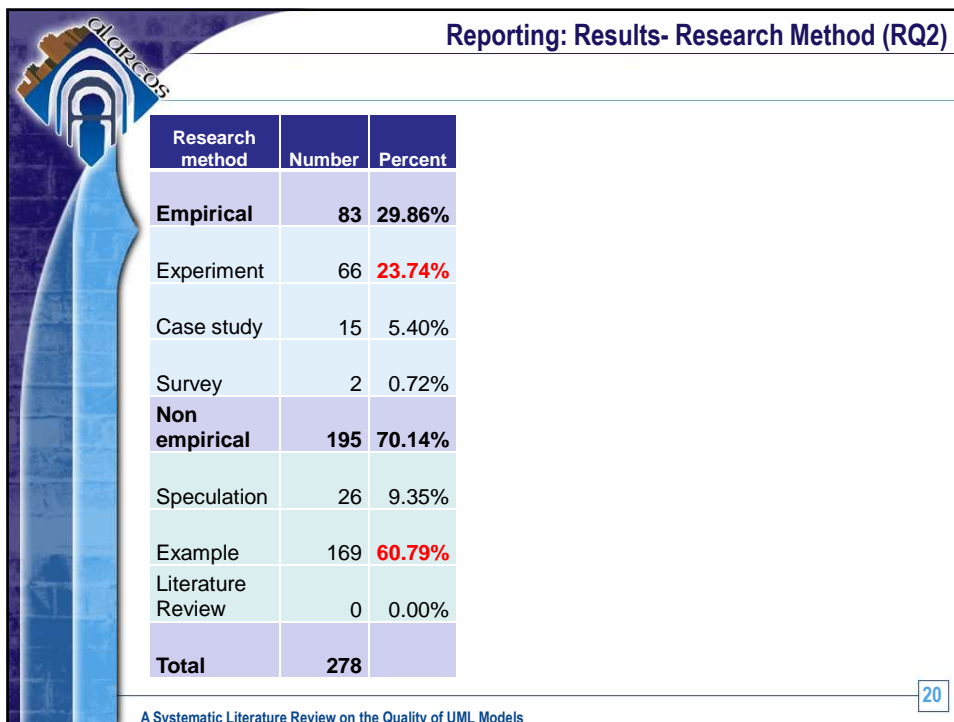
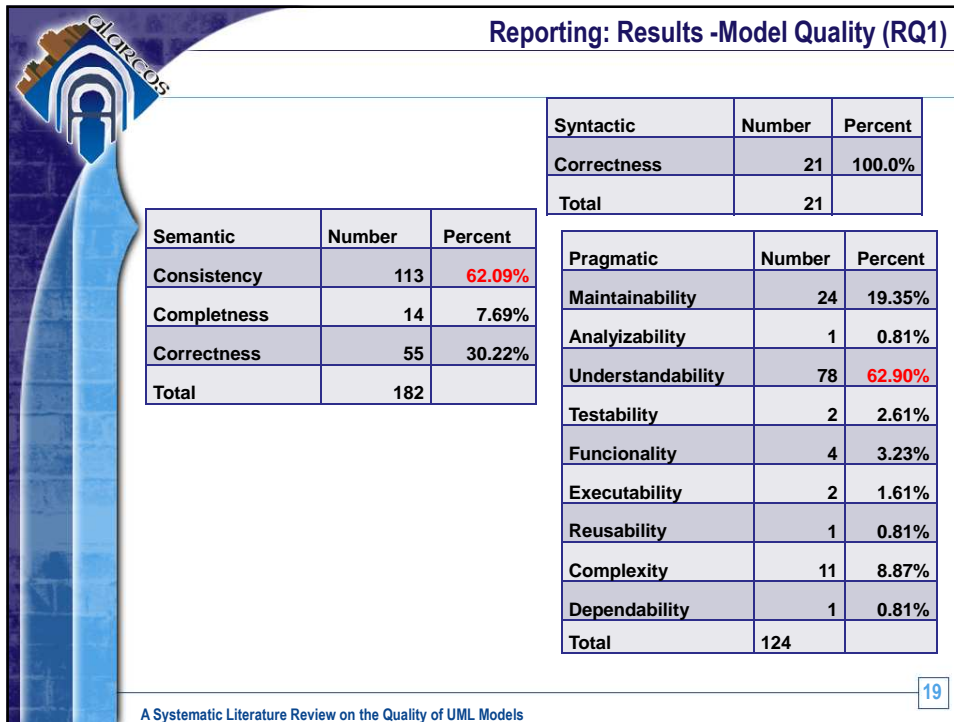


Reporting: Results -Model Quality (RQ1)

Type of quality	Number	Percent
Syntactic	15	5.64%
Semantic	135	50.75%
Pragmatic	103	38.72%
Syntactic + Semantic	6	2.26%
Syntactic + Pragmatic	0	0.00%
Semantic + Pragmatic	6	2.26%
Syntactic + Semantic + Pragmatic	1	0.38%
Total	266	100.00%

18

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Results: Research Method (RQ2)

Research method	Number	Percent	Syntactic		Semantic		Pragmatic	
Empirical	83	29.86%	2	9.09%	19	12.84%	62	57.41%
Experiment	66	23.74%	2	9.09%	9	6.08%	55	50.93%
Case study	15	5.40%	0	0.00%	9	6.08%	6	5.56%
Survey	2	0.72%	0	0.00%	1	0.68%	1	0.93%
Non empirical	195	70.14%	20	90.91%	129	87.16%	46	42.59%
Speculation	26	9.35%	2	9.09%	19	12.84%	5	4.63%
Example	169	60.79%	18	81.82%	110	74.32%	41	37.96%
Literature Review	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Total	278		22		148		108	

21

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Results: Research Results (RQ3)

Type of Result	Number	Percent
Formal semantics	3	1.01%
Framework	3	1.01%
Knowledge	55	18.46%
Method	119	39.93%
Metrics	28	9.40%
Notation	10	3.36%
Pattern	4	1.34%
Quality model	1	0.34%
Tool	50	16.78%
View	3	1.01%
Checklist, rules, modeling conventions, and guidelines	22	7.38%
Total	298	100.0%

22

A Systematic Literature Review on the Quality of UML Models

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23

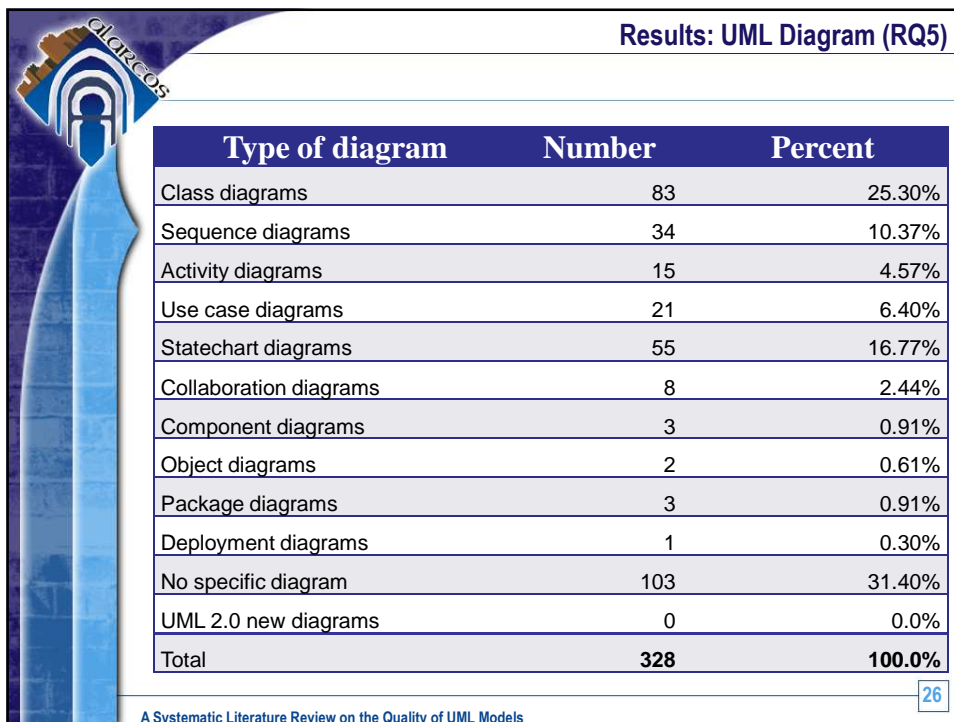
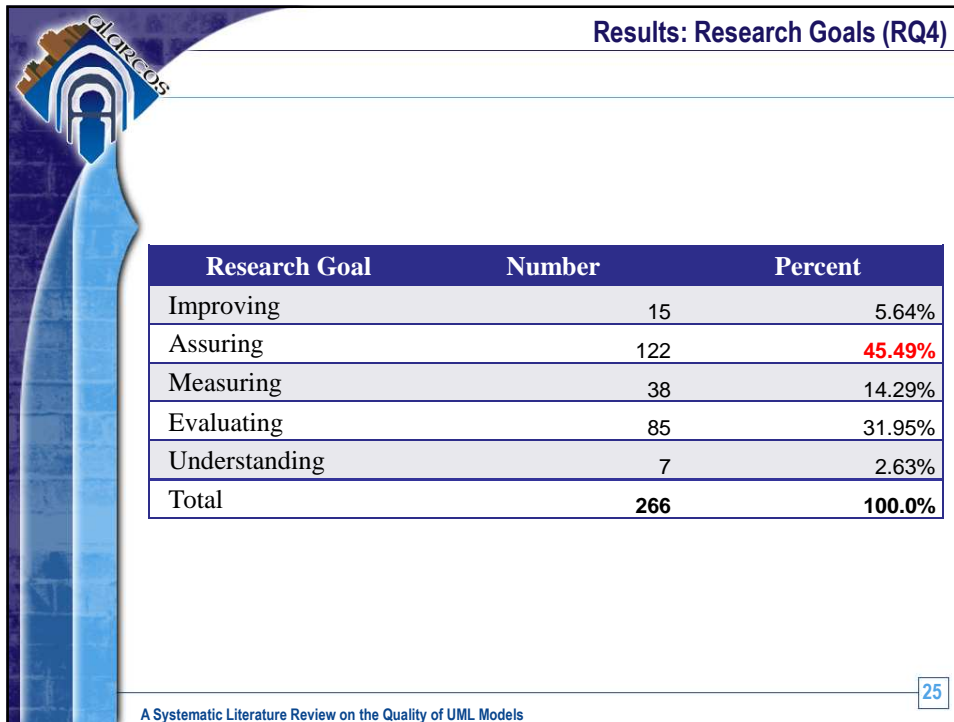
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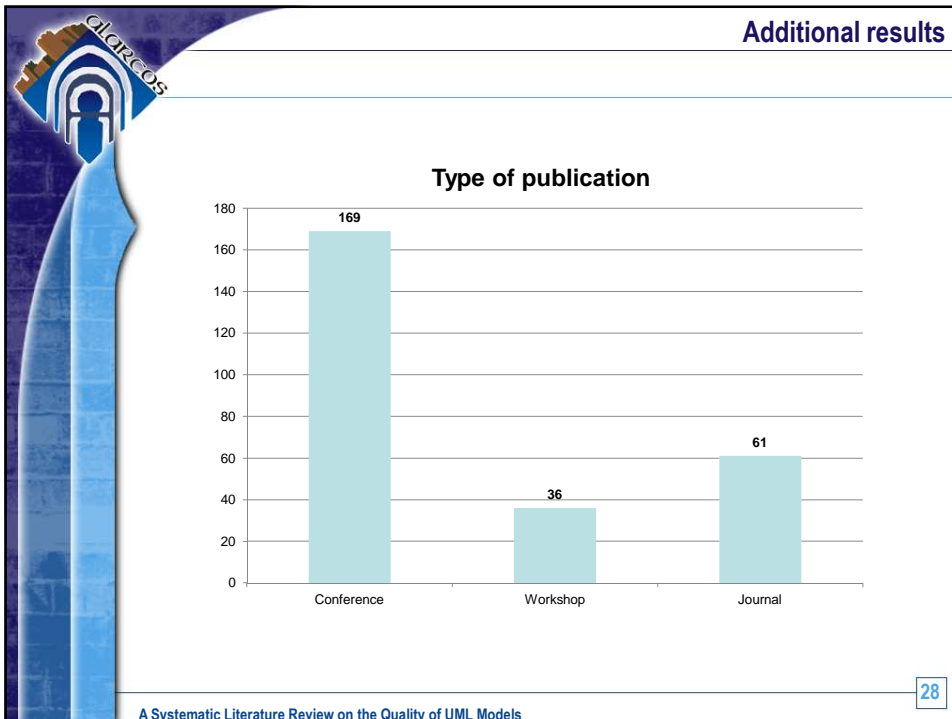
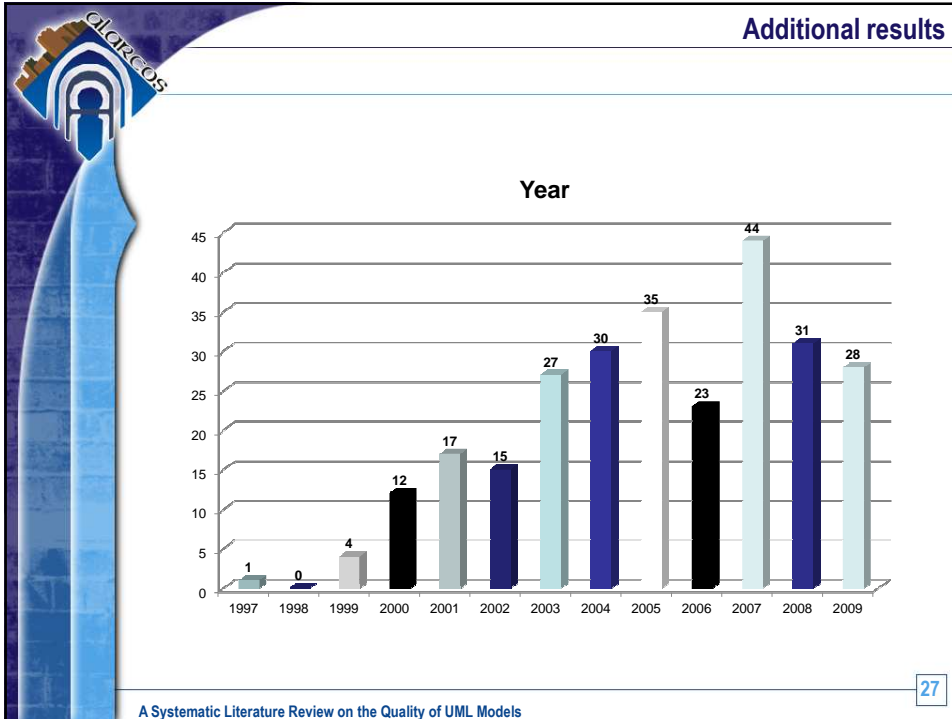
Results: Research Results (RQ3)


	Method	Knowledge	Tool	Metrics	Rule, modeling convention, checklist, guideline
Pragmatic	18.25%	76.06%	22.03%	91.18%	24.0%
Dependability	0.73%	0.00%	0.00%	0.00%	0.0%
Executability	0.73%	0.00%	3.39%	0.00%	0.0%
Functionality	1.46%	2.82%	0.00%	2.94%	0.0%
Maintainability	3.65%	9.86%	3.39%	26.47%	0.0%
Reusability	0.73%	0.00%	0.00%	0.00%	0.0%
Complexity	0.00%	1.41%	1.69%	23.53%	4.0%
Testability	0.00%	0.00%	1.69%	2.94%	0.0%
Understandability	10.95%	60.56%	11.86%	35.29%	20.0%
Analyzeability	0.00%	1.41%	0.00%	0.00%	0.0%
Semantic	74.45%	19.72%	62.71%	8.82%	72.0%
Completeness	4.38%	7.04%	3.39%	0.00%	8.0%
Consistency	55.47%	9.86%	38.98%	5.88%	48.0%
Correctness	14.60%	2.82%	20.34%	2.94%	16.0%
Syntactic	7.30%	4.23%	15.25%	0.00%	4.0%
Correctness	7.30%	4.23%	15.25%	0.00%	4.0%

24

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Lessons learned

- The abstracts are very poor → structured abstracts
 - Context (the importance and relevance of the research),
 - Objectives (the main objectives pursued)
 - Methods (the research method followed and the proposal provided to attain the objectives)
 - Results (the main findings and conclusions obtained).
- Limitation of the search engines
- Papers affirm that a case study has been carried out but they are only presenting application examples

29

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Conclusions and future work

- Conceptual modelling quality is an important topic, with academia and industry both recognizing that it is critical to “get the model right.”
- Only 29.86% of the proposals collected carried out some kind of empirical validation.
 - Need for empirical validation
 - Need of a repository of models
- UML model quality research seems to concentrate on three types of quality (syntactic, semantic, pragmatic).
 - Yet there is no consensus on the quality characteristics addressed nor on their definitions.
- The topic needs to mature.
 - Many more peer-reviewed articles published in leading journals are needed.

30

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