




INDEX

- Introduction
- Research questions
- Search strategy
- Search string
- Inclusion criteria
- Exclusion criteria
- Summary of found papers
- Results




Introduction

- Software = Complex → models
- Model Driven Development (MDD)
- Code quality → models quality
- UML = “standard” modeling language

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4




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?

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5




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

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6




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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Representation	Representation OR diagram OR model

↓

(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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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

9

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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

10

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Classification scheme

- Type of Diagram
 - 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)

11

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Classification scheme

- Type of Diagram
- Type of Quality
 - Syntactic**
 - Correctness
 - Semantic**
 - Consistency
 - Completeness
 - Correctness
 - Pragmatic**
 - Maintainability
 - Analyzability
 - Understandability
 - Testability
 - Functionality
 - Executability
 - Reusability
 - Complexity
 - Dependability

12

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Classification scheme

- Type of Diagram
- Type of Quality

Syntactic

- Correctness

Semantic


- Consistency
- Completeness
- Correctness

Pragmatic

- Maintainability
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13

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14

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Classification scheme

- Type of Diagram
- Type of Quality
- Type of evidence

Non empirical


- Speculation
- Example
- Literature review

Empirical

- Experiment
- Case study
- Survey

15

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Classification scheme

- Type of Diagram
- Type of Quality
- Type of evidence
- Type of result

quality model

notation

method, technique, methodology, process, approach, strategy or algorithm

tool

metric

knowledge


pattern

view

checklist, guideline, rule or modeling convention

16

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Classification scheme

- Type of Diagram
- Type of Quality
- Type of evidence
- Type of result
- Research goal

understanding

Measuring


evaluating

assuring

improving

17

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Summary of found papers

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	

18

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Summary of found papers

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 (75)
Apr 2010		Data synthesis		
Jul2010			Final report	

19

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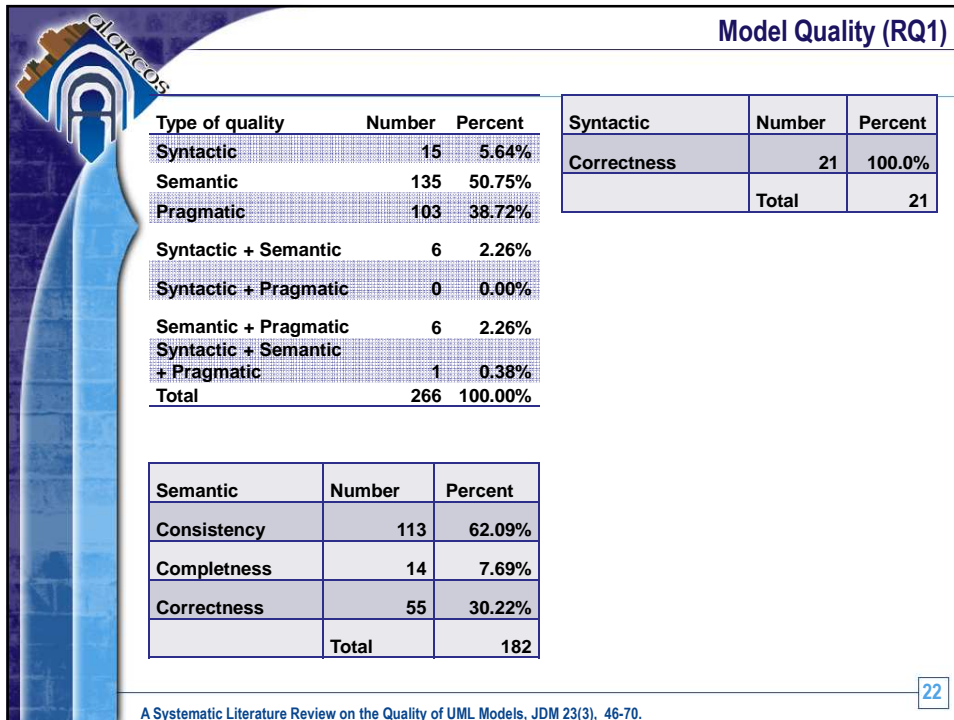
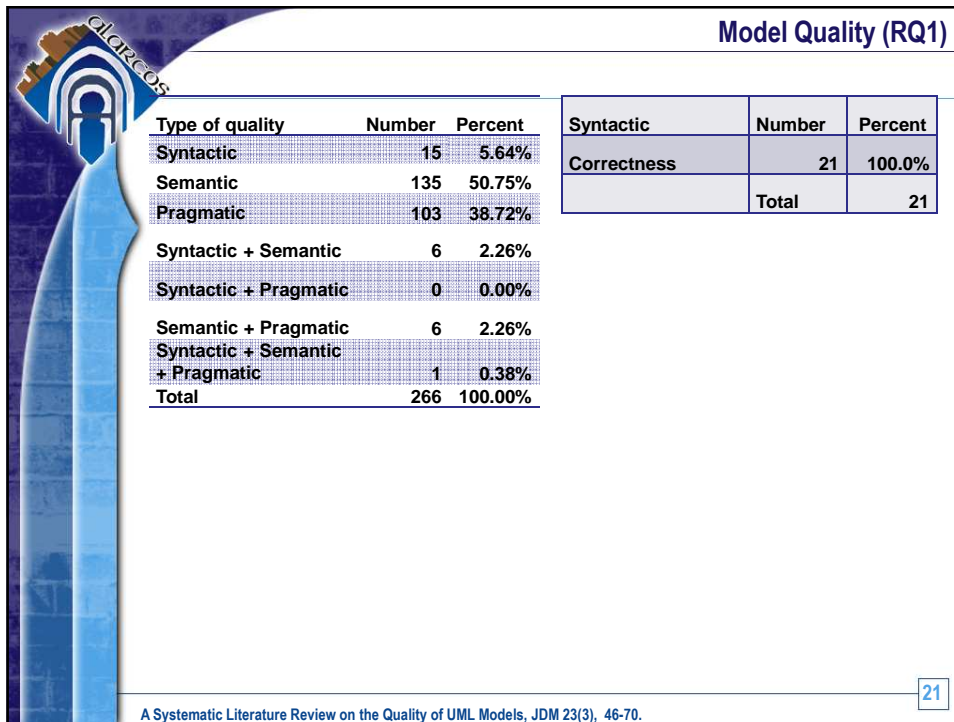


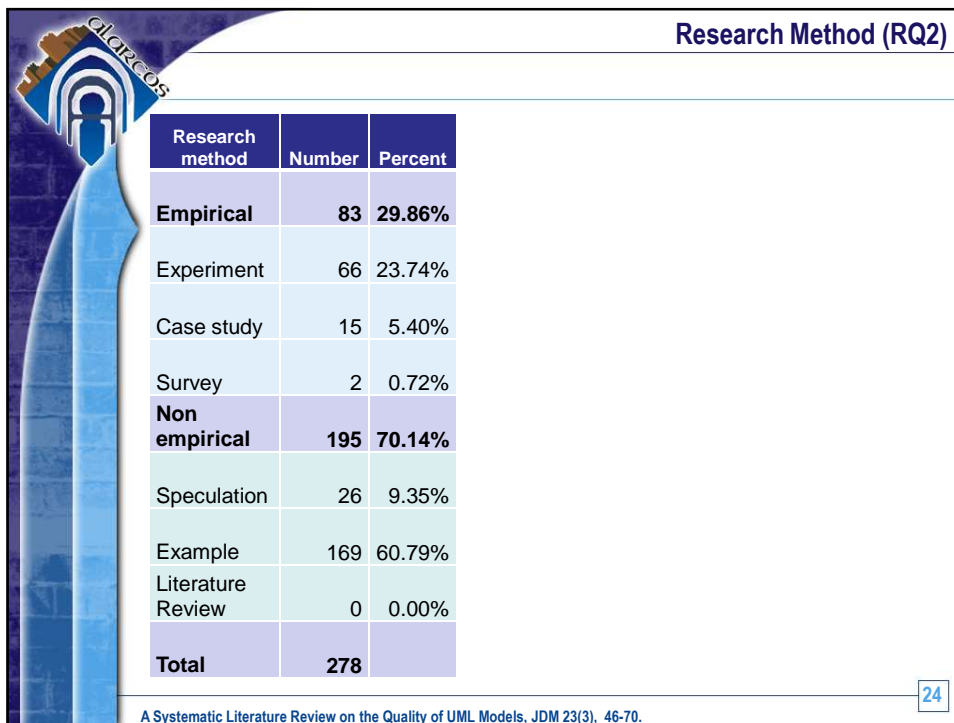
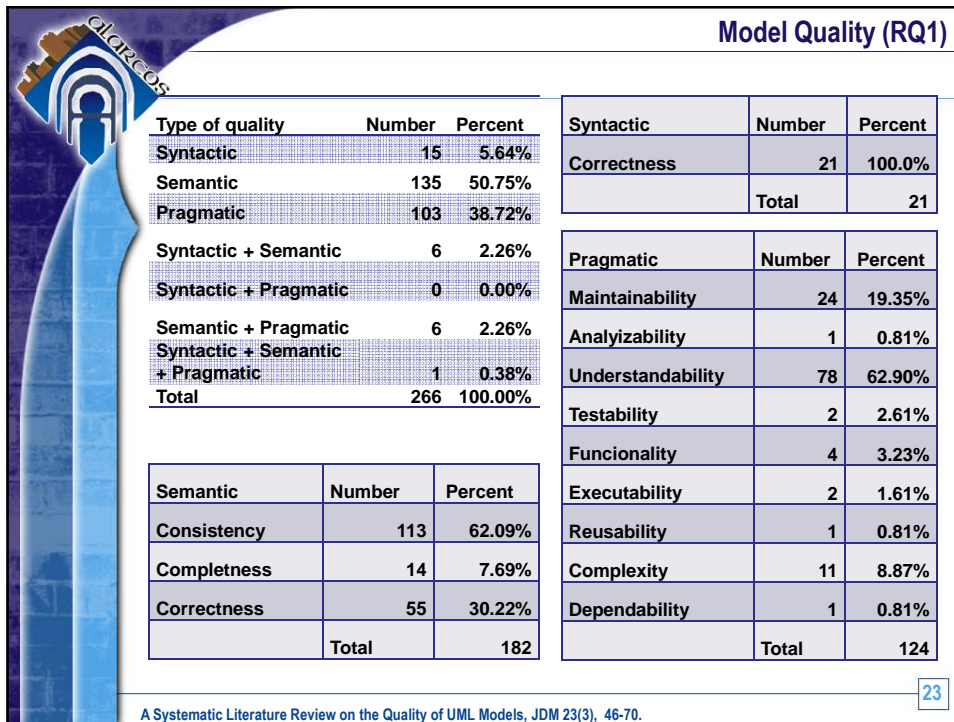
Model Quality (RQ1)


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%

20

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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	

25

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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%

26

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Research Goals (RQ4)

Research Goal	Number	Percent
Improving	15	5.64%
Assuring	122	45.49%
Measuring	38	14.29%
Evaluating	85	31.95%
Understanding	7	2.63%
Total	266	100.0%

27

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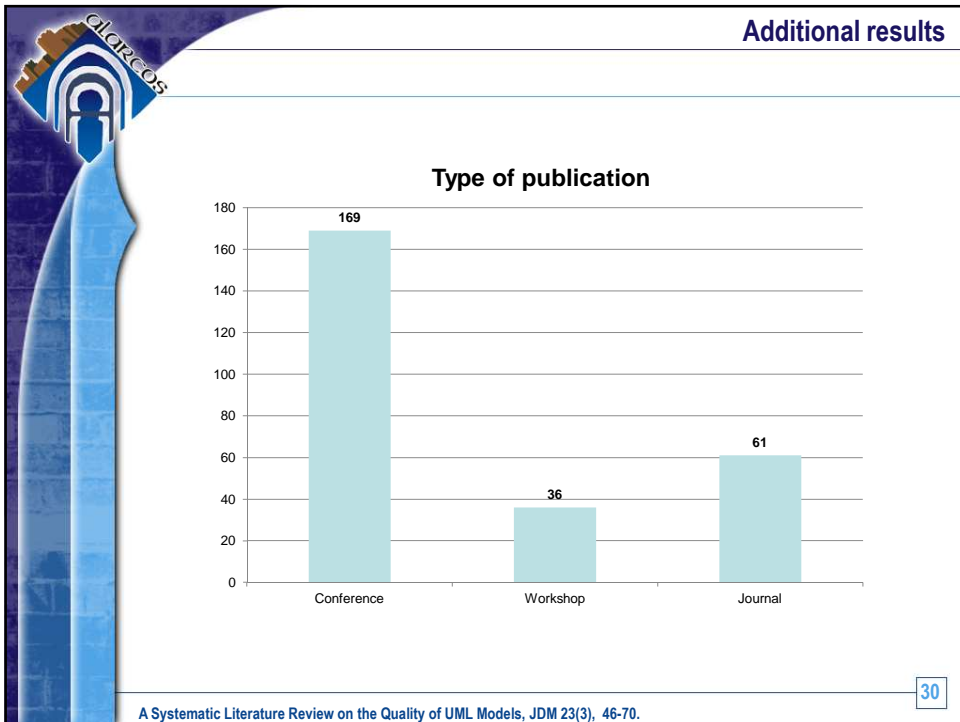
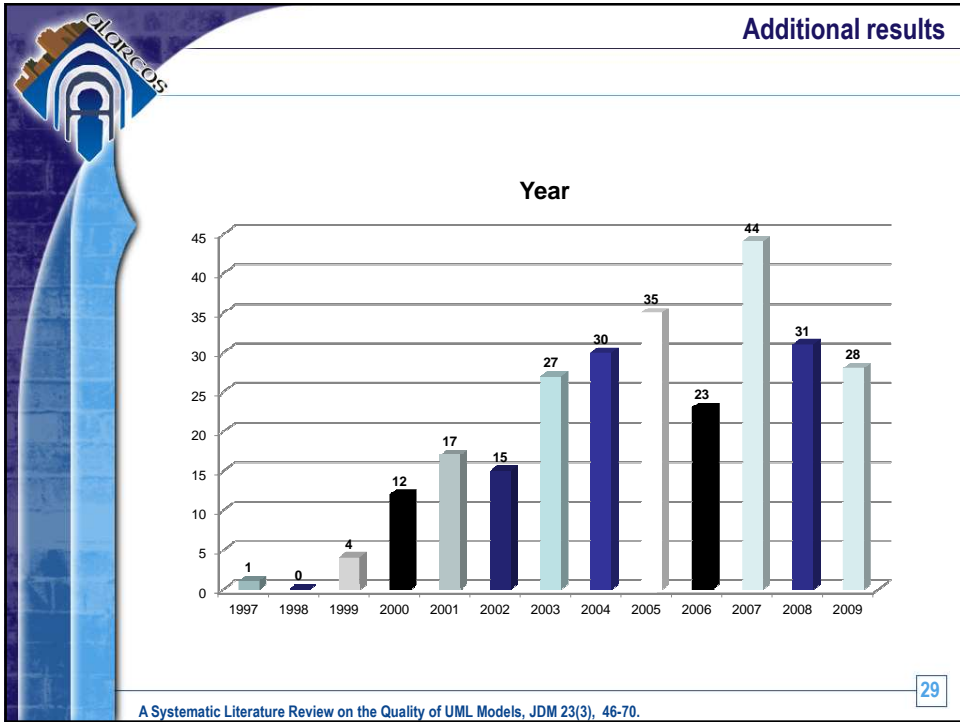



UML Diagram (RQ5)

Type of diagram	Number	Percent
Class diagrams	83	25.30%
Sequence diagrams	34	10.37%
Activity diagrams	15	4.57%
Use case diagrams	21	6.40%
Statechart diagrams	55	16.77%
Collaboration diagrams	8	2.44%
Component diagrams	3	0.91%
Object diagrams	2	0.61%
Package diagrams	3	0.91%
Deployment diagrams	1	0.30%
No specific diagram	103	31.40%
UML 2.0 new diagrams	0	0.0%
Total	328	100.0%

28

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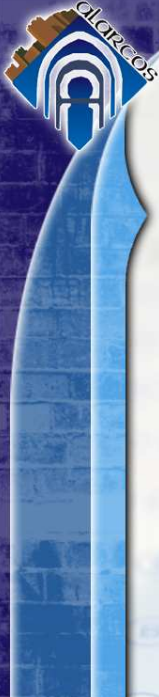


Lessons learned

- The abstracts are very poor
- Limitation of the search engines
- Papers affirm that a case study has been carried out but they are only presenting application examples

31

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**Marcela Genero, Ana M. Fernández, H. James
Nelson, Geert Poels, Mario Piattini**
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