

Contents

Declaration of Authorship	iii
Abstract	ix
Resum	ix
Resumen	xi
Acknowledgements	xv
1 The research context	1
1.1 Problem statement	1
1.2 Overview of the solution	3
1.3 Research methodology	3
1.3.1 Research questions	4
1.3.2 The research roadmap	4
2 Literature review about quality in MDE	7
2.1 Introduction	8
2.2 Quality issues in MDE	10
2.2.1 Evolution and limitations of the MDA standard	10
2.2.2 A literature review about models and modelling language quality trends	13
2.2.3 Results	16
2.2.4 Identified categories of the definition of <i>quality</i> in MDE	19
2.2.5 Adaptive sampling	24
2.2.6 Other findings	28
2.2.7 Discussion	31
2.2.8 The relationship between quality in MDE and V&V	32
2.3 A mismatch analysis between industry and academy field on MDE quality evaluation	32
2.3.1 Literature review process design	33
2.3.2 Detected categories for industrial quality issues	36
MDA is not enough	37
Implicit questions derived from the MDE adoption itself	37
Tools as a way to increase complexity	37
Organizational support for the adoption of MDE	38
2.3.3 Detected categories for academic/research quality issues	38
Hard operationalization of model-quality frameworks	38
Defects and metrics mainly in UML	38
Specificity in the scenarios for quality in models	39

	Software quality principles extrapolated at modelling levels	39
2.3.4	Findings in the literature review of mismatch	40
2.4	The sufficiency of current quality evaluation proposals	45
2.5	Open challenges in the evaluation of the quality of modelling languages in MDE contexts	47
2.5.1	Using multiple modelling languages in combination	49
2.5.2	Assessing the compliance of modelling languages with MDE principles	50
2.5.3	Explicitly using abstraction levels as quality filters of modelling languages	51
2.5.4	Agreeing on a set of generic quality metrics for modelling languages	51
2.5.5	Including model transformations in the modelling language quality equation	52
2.5.6	Acknowledging the increasing dynamics of models	54
2.5.7	Streamlining ontological analyses of modelling languages	55
2.5.8	Incorporating modelling language quality as a source of technical debt in MDE	56
2.6	Conclusions	57
3	MMQEF: the conceptual and methodological framework	61
3.1	Introduction	61
3.2	The research problem	62
3.2.1	Conceptual approaches for addressing quality issues in MDE	63
3.2.2	The reference taxonomy	64
3.2.3	The support of the taxonomy for MDE quality issues	66
3.3	The MMQEF method	67
3.3.1	Purposes and preconditions	67
3.3.2	Method components	68
3.3.3	Cooperation principles	69
	Structure	69
	Roles	69
3.3.4	The main quality evaluation method components	69
3.3.5	MDE quality analytics derived	71
	Inference analysis derived from the Zachman taxonomy	72
	Derived supports for MDE quality evaluation	73
3.3.6	Tool support	76
3.3.7	An example application of the MMQEF method	76
3.4	Preliminary trade-off analysis of the MMQEF method	83
3.4.1	Main implications of the MMQEF method	83
	Why taxonomy analysis?	83
	Why this taxonomy?	84
	Is it the only taxonomy? Why not a quality ontology instead?	84
3.4.2	Feasibility of the classification procedure for quality purposes	85
3.4.3	The use of the taxonomic structure itself	85
3.4.4	MMQFE and other quality frameworks for MDE	88

3.5	Conclusions	89
4	The formal and technological support of the MMQEF method	91
4.1	Introduction	91
4.2	The taxonomic analysis and the MMQEF method	93
4.2.1	The formal support of the taxonomy for the quality evaluation analysis of modelling artifacts	96
4.2.2	The Zachman framework as a taxonomic theory	98
4.2.3	Related works	99
4.3	The FCA method	100
4.3.1	The FCA support for the taxonomic analysis	101
4.4	The EMAT Tool	103
4.4.1	Why is another FCA tool needed? Is EMAT another FCA tool?	103
4.4.2	The taxonomic evaluation procedure using EMAT	103
4.4.3	How should a resulting lattice be interpreted ?	105
4.4.4	Other complementary functions	106
4.4.5	EMAT architecture and future vision	107
4.4.6	A trade-off analysis of the EMAT tool	109
4.5	MMQEF and EMAT in practice	110
4.5.1	Quality analysis of the UML and BPMN modelling languages	110
4.5.2	Quality analysis of the OO-Method and CA integration .	114
4.6	Discussion	117
4.6.1	Why another quality framework for MDE?	119
4.7	Conclusions	124
5	Theoretical validation of the taxonomy used by MMQEF	125
5.1	Taxonomies and Information Systems	126
5.2	Is the Zachman taxonomy the only one that classifies modelling languages?	128
5.2.1	Results	129
5.3	The previous use of the taxonomy to classify modelling languages	133
5.4	Conclusions	135
6	Empirical Evaluation of MMQEF	137
6.1	Introduction	138
6.1.1	Overview of quality methods for MDE	139
6.1.2	Problem Statement	140
6.1.3	Research objective	141
6.1.4	Context	141
6.2	Design of the experiments	143
6.2.1	Experimental units	143
6.2.2	Experimental material	144
6.2.3	Tasks	145
6.2.4	Hypotheses, parameters, and variables	146
6.2.5	Analysis procedure	147
6.2.6	Execution - deviations	149
6.3	Analysis	149

6.3.1	Descriptive analysis	149
6.3.2	Testing of hypotheses	155
	Analysis of the MEM variables for MMQEF	160
6.4	Discussion	165
6.4.1	Evaluation of results and implications	165
6.4.2	Threats to Validity	165
6.4.3	Inferences	165
	The selection of <i>practical</i> methods.	166
	Detected reasons for choosing quality methods	166
	<i>Representations</i> as an important source for quality evaluation procedures.	167
	The need for a modelling context	168
	Perceived independence of the quality proposals	168
6.4.4	Lessons learned	168
	The improvement of the procedure for making inferences in MMQEF	168
6.4.5	The improvement of the documentation for MMQEF	169
6.4.6	Improving the process of selection and characterization of participants	169
6.4.7	Validating specific features of quality methods for MDE individually instead of all together	169
6.5	Conclusions	170
6.5.1	Summary	170
6.5.2	Impact	170
6.5.3	Future work	171
6.6	Evidence of MMQEF applicability from the opinions of participants	171
6.7	Analysis of validity threats.	175
6.8	Raw data	178
7	The forthcoming research roadmap	179
7.1	The formulation of application scenarios for MMQEF	179
7.2	The support of MMQEF to address the quality issues reported from industrial contexts	180
7.3	The consolidation of operative support for the MMQEF	180
7.4	The consolidation of a set of metrics for modelling languages	181
7.5	The management of interaction issues in modelling languages (HCI of modelling languages)	181
7.6	The promotion of MMQEF as a <i>Type V Theory</i> for IS	182
8	Final considerations	183
8.0.1	Derived publications	183
	Journal article	184
	Book chapter	184
	Proceedings in conferences	184
	Technical reports	185
8.0.2	Research collaborations	185

A	A multiple modelling languages quality scenario	187
	A.0.3 Application of multiple models	189
	Business modelling models	190
	System models	192
	A.0.4 The first signs of quality problems	194
	Semiotic clarity	195
	Perceptual Discriminability	197
	Semantic Transparency	197
	Visual Expressiveness	198
	Complexity Management	198
	Dual Coding	198
	Graphic Economy	199
	A.0.5 Limitations of the selected approach to evaluate the quality of the models of the modelling scenario	199
B	The process-delivery diagram (PDD) specification for the MMQEF method	203
	Bibliography	213
	Index	226