Tirocinio interno:

Software Quality Models and Metrics: a Survey

Federica V. Maira

Relatore

Prof. Massimo Torquati

Università di Pisa
Dipartimento di Informatica

Pisa, 21 luglio 2023

Software Quality:

- What is it?
- Why is it so important?
- How to measure it?

What is it?

- Common visions:
  - it can not be quantified
  - the more expensive it is, the more quality it has

- Gaffney (1978): “It is more informative to determine the characteristics of high-quality software rather than define software quality”

- IEEE (1990): “the degree to which a software meets established requirements”

- S. Kan (2003): “conformance to customer’s requirements”

Why is it so important?

- Satisfy customer expectations
- Reduce costs
- Standard compliance
- Improve efficiency and reliability
- More competitiveness

How to measure it?

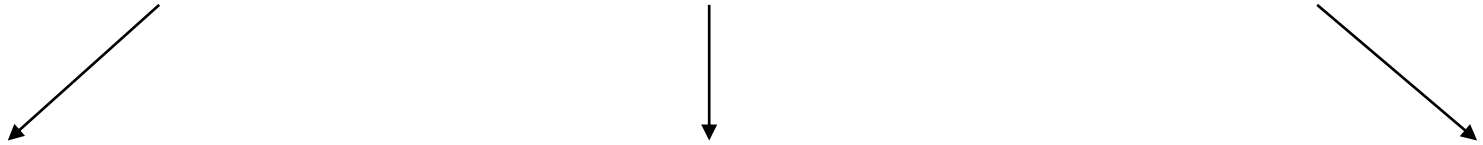
Software Quality Assessment is the process that
assesses quality during Software Development Life Cycle

- Qualitative approach → Models through factors and criteria
  (e.g., factor Maintainability in ISO 9126 has “Changeability or Testability” as two of its criteria)
- Quantitative approach → Metrics
  (e.g. Cyclomatic Complexity or Cognitive Complexity)

Software Quality Model

A model is a set of characteristics which describes the quality of a software using factors and their criteria
(e.g., reliability, security, usability…)

Thapar and Miguel classification



Basic	Tailored	Open-Source
(1977-2001)	(since 2001)	(since 2003)

S. S. Thapar, P. Singh and S. Rani, “Challenges to the Development of Standard Software Quality Model,” International Journal of Computer Applications, 2012
J. P. Miguel, D. Mauricio and G. Rodríguez, “A Review of Software Quality Models for the Evaluation of Software Products,” International Journal of Software Engineering & Applications, p. 24, 1814

Basic Models	***Tailored Models***	***Open-Source Models***
McCall (1977)	Bertoa (2001)	Cap Gemini (2003)
Boehm (1978)	GEQUAMO (2003)	OpenBRR (2005)
FURPS (1987), FURPS+ (2000)	Ortega (2003)	SQO-OSS (2008)
CMM (1991), CMMI (2002)	Alvaro (2005)	QualOSS (2010)
ISO 9126 (1991), ISO 25010 (2007)	Rawashdeh (2006)	
Dromey (1995)		

Software Quality Metrics

Quantitative measure that evaluates one or more quality characteristics of a software

- Product (or code) metrics:

  measure final product and target achievement
  (e.g., LOC, number of errors, cyclomatic complexity)
- Process metrics:

  measure the development life cycle of the software system
  (e.g., lead time, cycle time, defect density)
- Project metrics:

  involve project characteristics and execution
  (e.g., costs, number of developers, schedule, productivity)

```c
int main(){

    int vg = 55;

    if (x > 50)
        printf("Untestable code, very high risk");

}
```

Cyclomatic Complexity
$v(G) = e - n + 2p = 2$

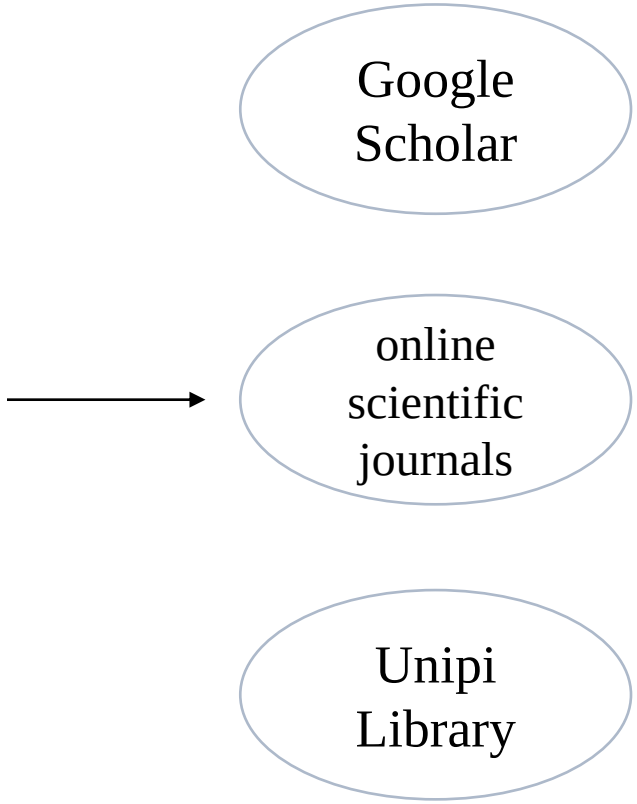
```c
int main(){

    int vg = 0;

    switch(x){
      case 0:  printf("Error, the minimum is 1"); break;
      case 1:  printf("Very simple procedure, no risk"); break;
      case 2:  printf("Simple procedure, no risk"); break;
      case 7:  printf("Simple procedure, little risk"); break;
      case 15: printf("More complex, moderate risk"); break;
      case 30: printf("Complex, high risk"); break;
      case 50: printf("Untestable code, very high risk"); break;
    }
}
```

Cyclomatic Complexity
$v(G) = e - n + 2p = 8$

Method of study

Keywords:

software quality models
software quality models
software quality assessment,
software quality evolution,
software quality evaluation,
software quality basic models,
software quality tailored models



Excel spreadsheet
subvided into tabs:

- List of papers
- Table
- Models Papers
- Metrics Papers
- Full List

The Excel file and the thesis are available open-source on the platform Github for further study.

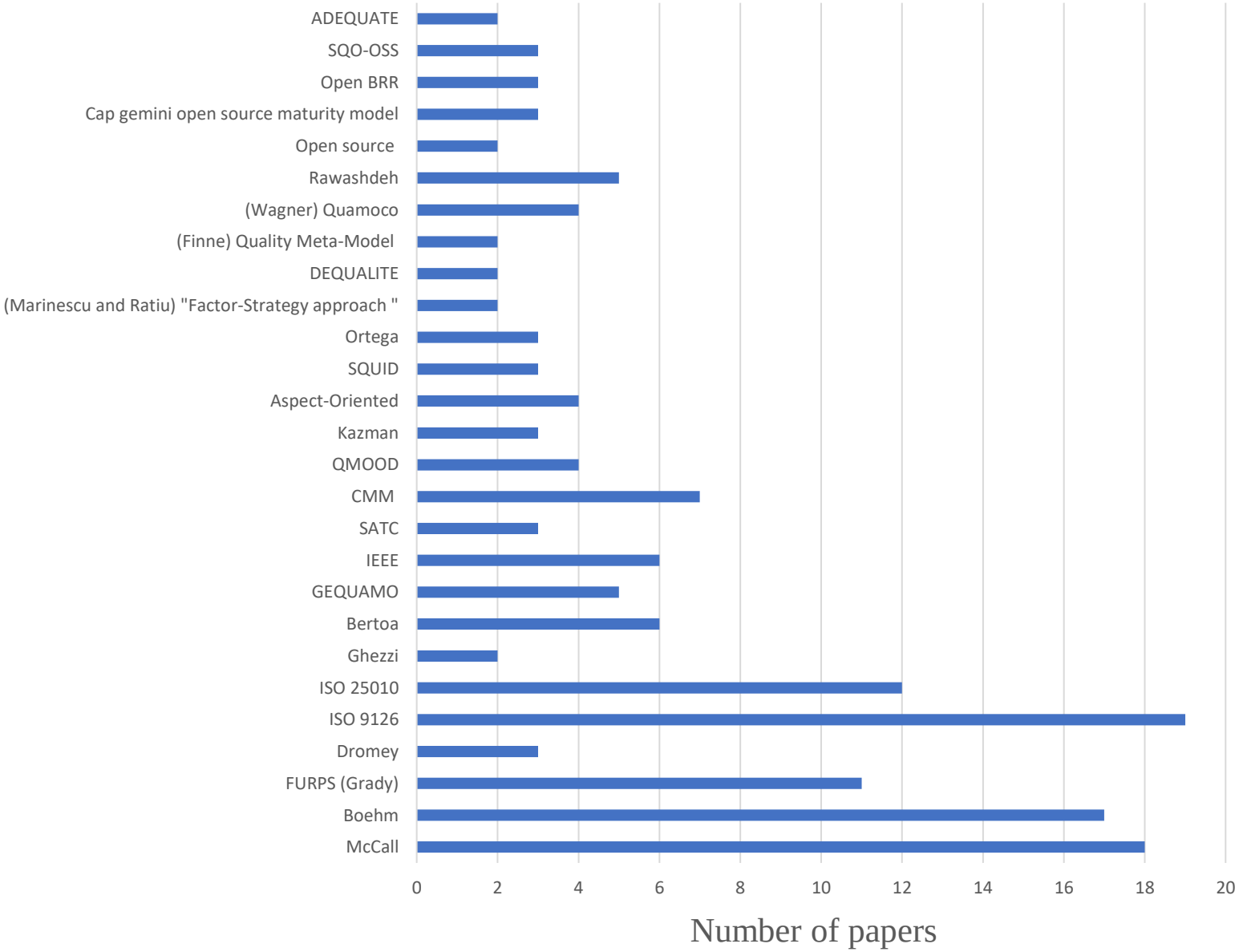
https://github.com/fmaira/SWQualityModelsMetrics.git

Number of text	***Sources***	***Years***
68 total 33 analysed 29 available in the table	Google Scholar, ACM, IEEE, ResearchGate, Taylor and Francis Online, CiteSeer, Addison-Wesley editor, and other online scientific journal	1978-2023

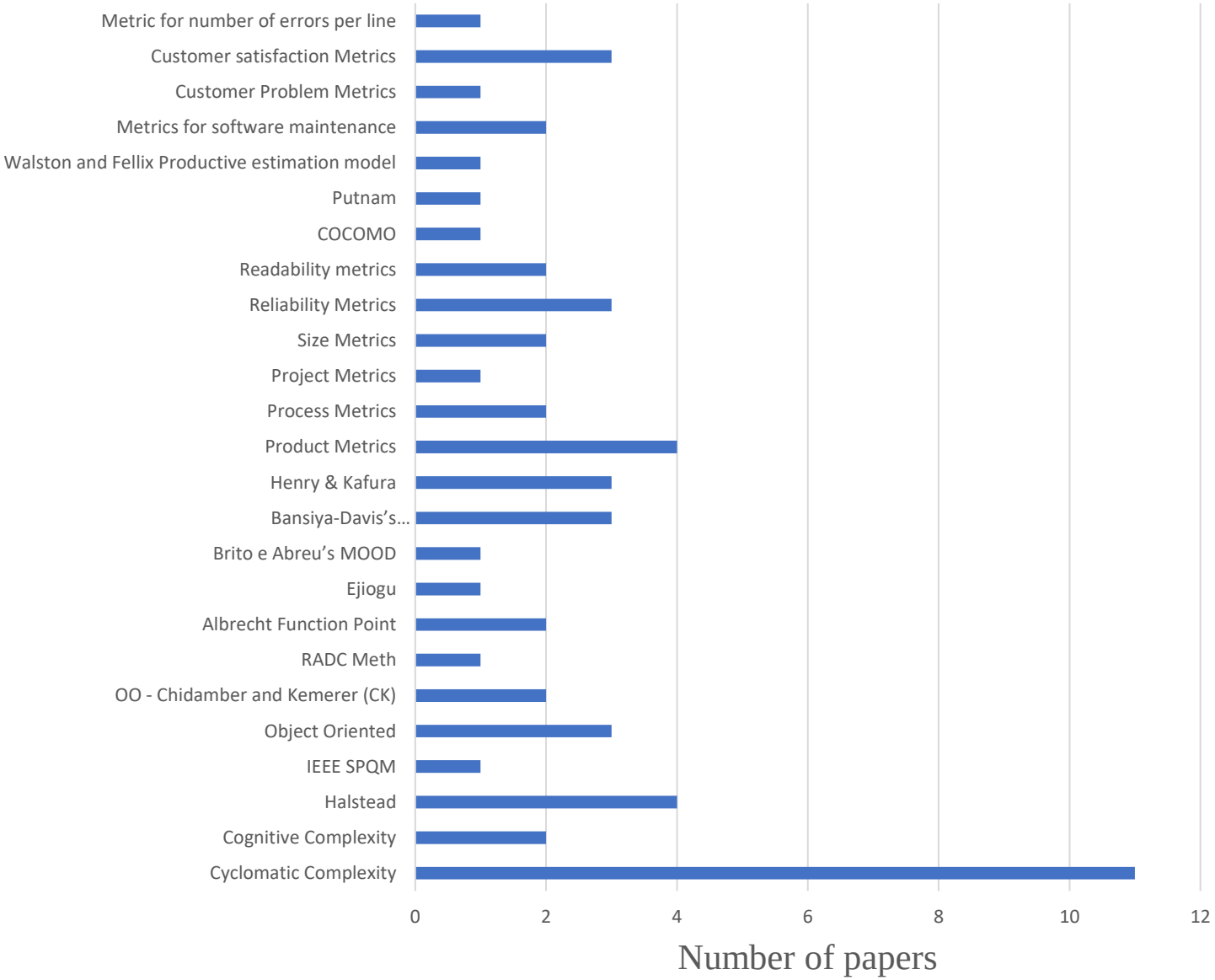
	A	B	C	D	E	F	G
1	TYPE	TITLE	YEAR	CITED BY (2.06.2023)	Published	NOTES	TABLE
2	PAPER	*A Review Report on Software Quality Measurement and Estimation*	2023	na	techrxiv.org		Y
3	PAPER	*Assessing the Impact of Software Quality Models in Healthcare Software Systems*	2023	na	Taylor & Francis Online		Y
4	PAPER	*Does Cyclomatic or Cognitive Complexity Better Represents Code Understandability?*	2023	na	arXiv Forum		Y
5	PAPER	*How have Views on Software Quality Differed over Time? Research and Practice Viewpoints*	2023	1	Taylor & Francis Online		Y
6	PAPER	*Software Product Quality Metrics a Systematic Mapping Study*	2021	21	IEEE		Y
7	PAPER	*Cognitive Complexity: A New Way of Measuring Understandability*	2021	na	sonarsource.com	version 1.5	
8	TESI	*Un Metodo di Analisi Statica di Qualità del Software*	2020	na	Bologna University		Y
9	PAPER	*Analysis and Assessment of Existing Software Quality Models to Predict the Reliability of Component-Based Software*	2020	16	International Journal of Emerging Trends in Engineering Research		Y
10	PAPER	*Software Product Quality Models, Developments, Trends, and Evaluation*	2020	15	SN Computer Science		Y
11	PAPER	*Software Quality Models a Systematic Mapping Study*	2019	46	IEEE		Y
12	BOOK	*Managed Software Evolution*	2019	33	oapen.org	chap 2 pag 29	Y
13	PAPER	*The Criteria for Software Quality in Information*	2019	6	International Journal of Advanced Computer Science and Applications	pages 79-85	Y
14	PAPER	*Analysis of Software Quality using Software Metrics*	2018	11	International Journal on Computational Science &		Y
15	WEBSITE	*Software Application Development Company: Types of Software Quality Models*	2016	na	https://www.blogger.com/dashboard/reading		Y
16	PAPER	*Software Quality Assessment Tool Based On Meta-Models*	2015	2	International Journal of Computer Science and Mobile Computing		Y
17	PAPER	*A Review of Software Quality Models for the Evaluation of Software Products*	2014	287	International Journal of Software Engineering & Applications		Y
18	PAPER	*Software Quality Factors and Software Quality Metrics to Enhance Software Quality Assurance*	2014	65	British Journal of Applied Science & Technology		Y
19	PAPER	*A Comparative Study of Software Quality Models*	2014	44	International Journal of Computer Science and Information Technologies		Y
20	PAPER	*Challenges to the Development of Standard Software Quality Model*	2012	28	International Journal of Computer Applications	see table pag 3 https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=b61e2881fa7242887aec53e47069be2d28673940	Y
21	THESIS	*Automatic Measurement of Source Code Complexity*	2011	22	SemanticScholar		Y
22	PAPER	*A Software Component Quality Framework*	2010	47	ACM		Y
23	PAPER	*FreeLibre Open Source Quality Models - a comparison between two approaches*	2010	21	CiteSeer		N
24	PAPER	*Quantitative Evaluation of Software Quality Metrics in Open-Source Projects*	2009	99	ResearchGate		N
25	PAPER	*The SQO-OSS Quality Model Measurement Based Open Source Software Evaluation*	2008	212	Springer	pag 237-248	N
26	PAPER	*A New Software Quality Model for Evaluating COTS Components*	2006	174	Journal of Computer Science		Y
27	BOOK	*Ingegneria del Software - Creatività e Metodo*	2006	5	Addison Wesley	chapter 2 "Qualità del Software	N
28	PAPER	*Towards a Software Component Quality Model*	2005	34	CiteSeer		Y
29	BOOK	*Metrics and Models in Software Quality Engineering*	2003	2444	Addison Wesley	chapter 1	N
30	PAPER	*GEQUAMO - A Generic, Multilayered, Customisable, Software Quality Model*	2003	62	Software Quality Journal		Y
31	PAPER	*QUIM A Framework for Quantifying Usability Metrics in Software Quality Models*	2001	94	IEEE		Y
32	BOOK	*Structured Testing: A Testing Methodology Using the Cyclomatic Complexity Metric*	1996	552	Dolores R. Wallace Editor	NIST Special Publication	Y
33	PAPER	*Metrics In Software Quality Assurance*	1981	111	ACM		Y
34	PAPER	*A Framework for the Measurement of Software Quality 1978*	1978	395	ACM		Y

List of the texts involved in the research

In how many papers appear each models



In how many papers appear each metric



Results:

Most common model	ISO 9126
Most cited standard	IEEE
Most common metric	Cyclomatic Complexity
Most common factor	Reliability

Results:

Most cited text in Google Scholar	«*Metrics and Models in Software Quality Engineering*» by Stephan Kan, 2003
Paper that provides a wider range of models	«*Analysis and Assessment of Existing Software Quality Models to Predict the Reliability of Component-Based*» by Shivani and Bal, 2020
Paper that provides a wider range of metrics	«*Software Quality Factors and Software Quality Metrics to Enhance Software Quality Assurance*» by Lee M. C., 2014

Thanks for your attention