

Putting Software Testing Terminology to the Test

M.A.Sc. Seminar

Samuel Crawford, B.Eng.

McMaster University
Department of Computing and Software

Fall 2024

Table of Contents

1 Introduction

- The Need for Standardized Terminology
- The Lack of Standardized Terminology

2 Project

- Research Questions
- Methodology

3 Results

Table of Contents

1 Introduction

- The Need for Standardized Terminology
- The Lack of Standardized Terminology

2 Project

- Research Questions
- Methodology

3 Results

The Need for Standardized Terminology

- Engineering is applied science
- Scientific fields use precise terminology



SOFTWARE
ENGINEERING

The Need for Standardized Terminology

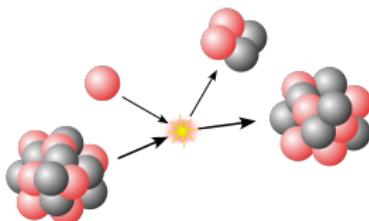
- Engineering is applied science
- Scientific fields use precise terminology



SOFTWARE
ENGINEERING



Penubag and Ramey (2010)



Kjerish (2016)



AzaToth (2008)

The Lack of Standardized Terminology

"The Problem"



(ISO/IEC and IEEE, 2022, Fig. 2)

The Lack of Standardized Terminology

"The Problem"

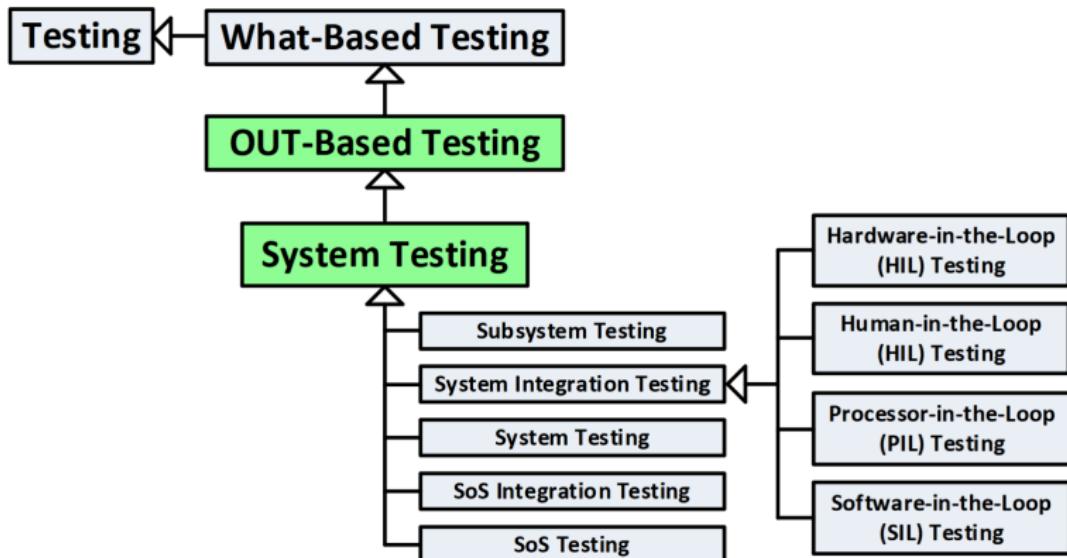


Adapted from (ISO/IEC and IEEE, 2022, Fig. 2)

The Lack of Standardized Terminology

“The Problem” (cont.)

What: by Object Under Test (OUT) – System Testing

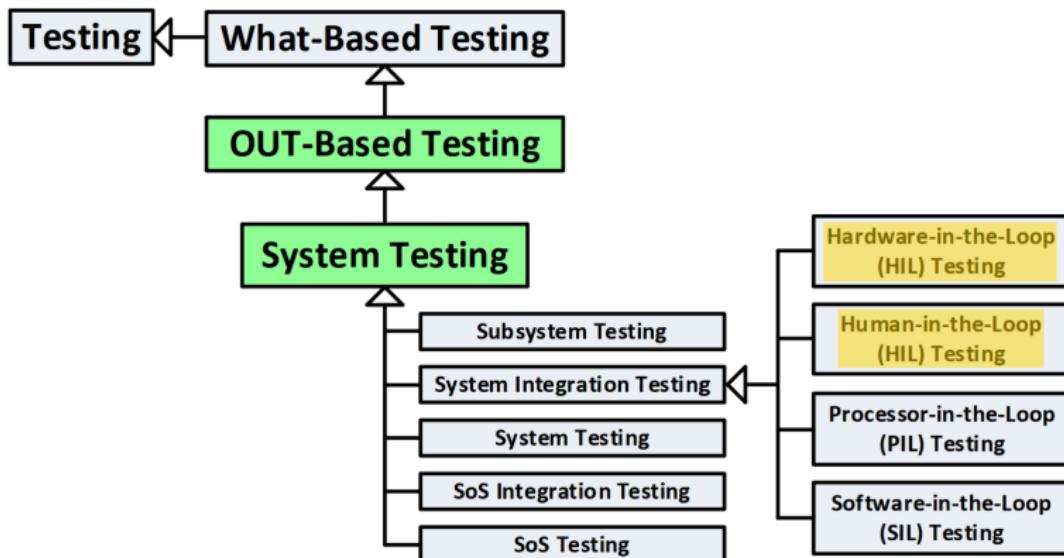


(Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

What: by Object Under Test (OUT) – System Testing

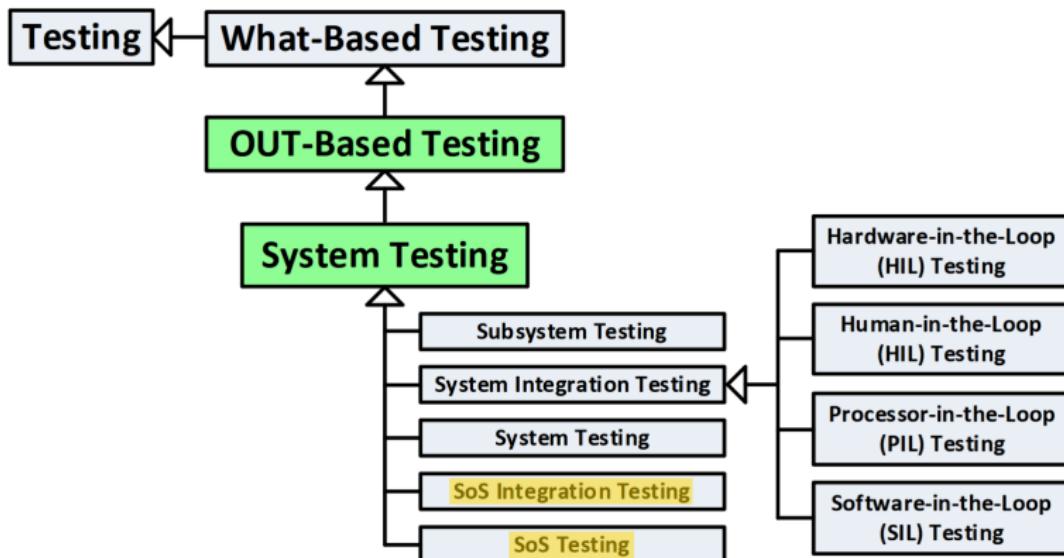


Adapted from (Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

What: by Object Under Test (OUT) – System Testing

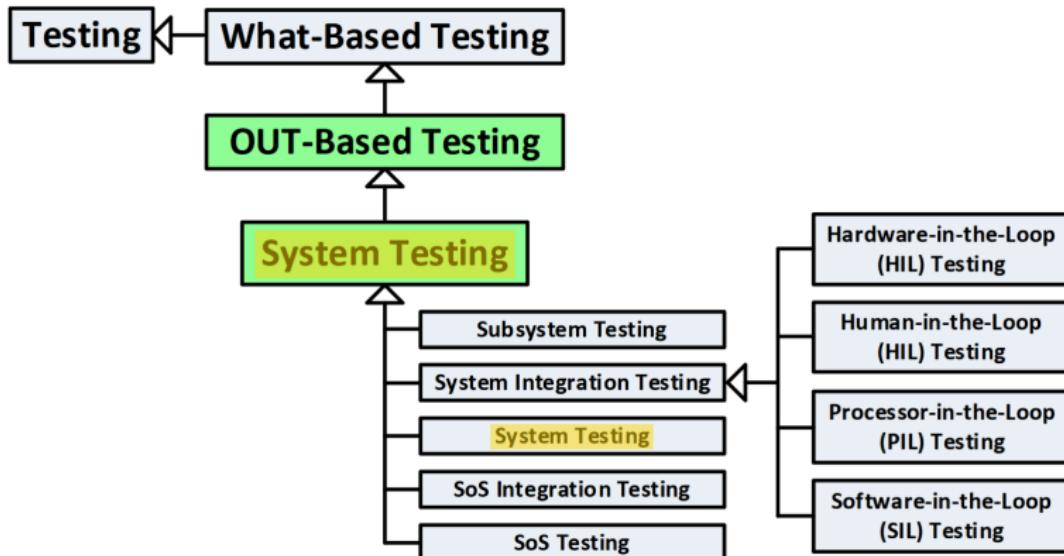


Adapted from (Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

What: by Object Under Test (OUT) – System Testing

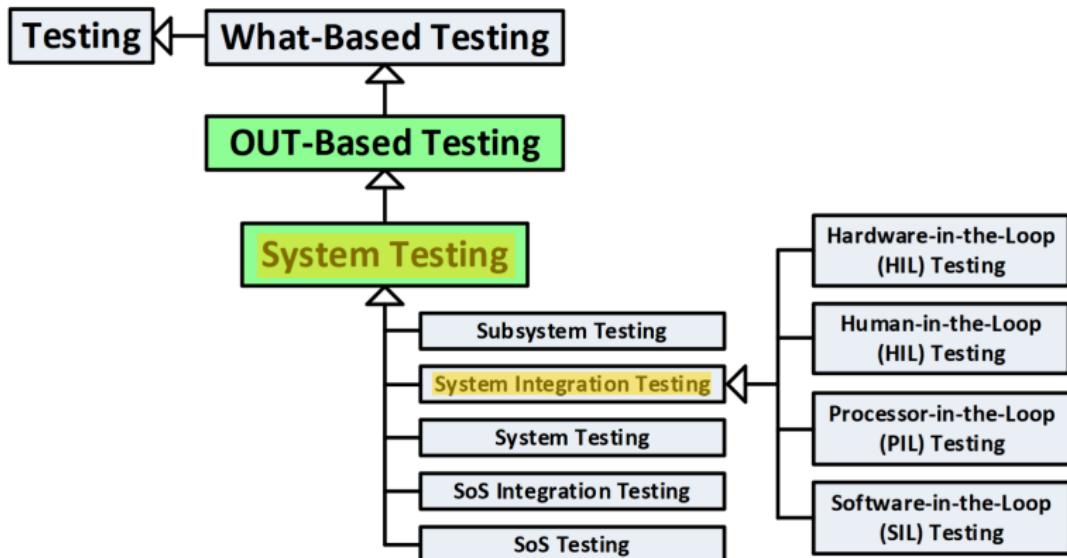


Adapted from (Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

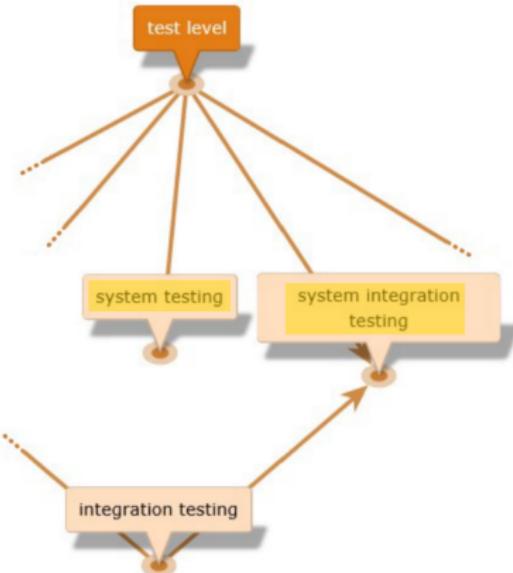
What: by Object Under Test (OUT) – System Testing



Adapted from (Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)



Adapted from (Hamburg and Mogyorodi, 2024)

What-Based Testing

OUT-Based Testing

System Testing

Subsystem Testing

System Integration Testing

System Testing

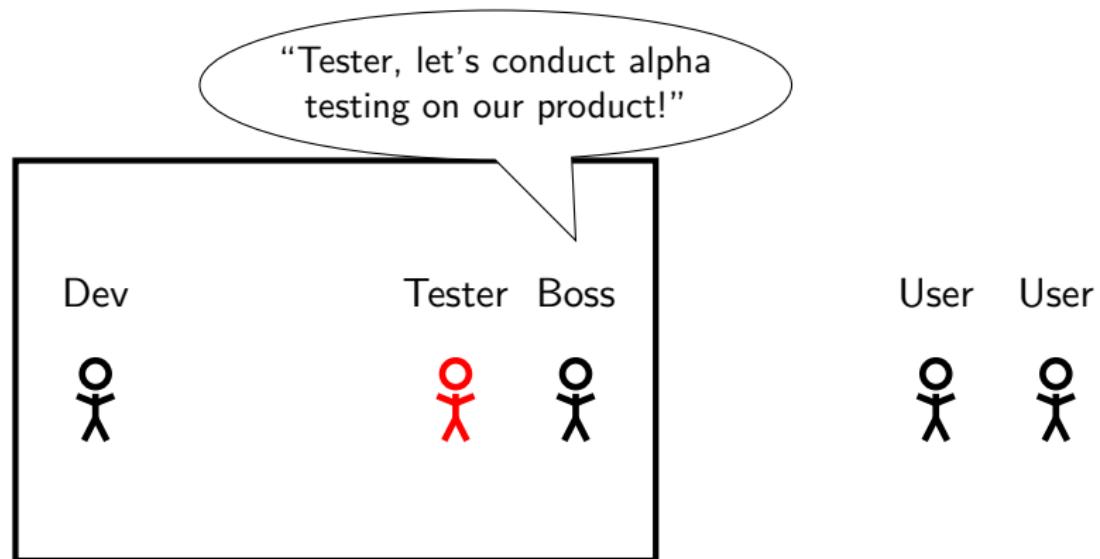
SoS Integration Testing

SoS Testing

Adapted from (Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

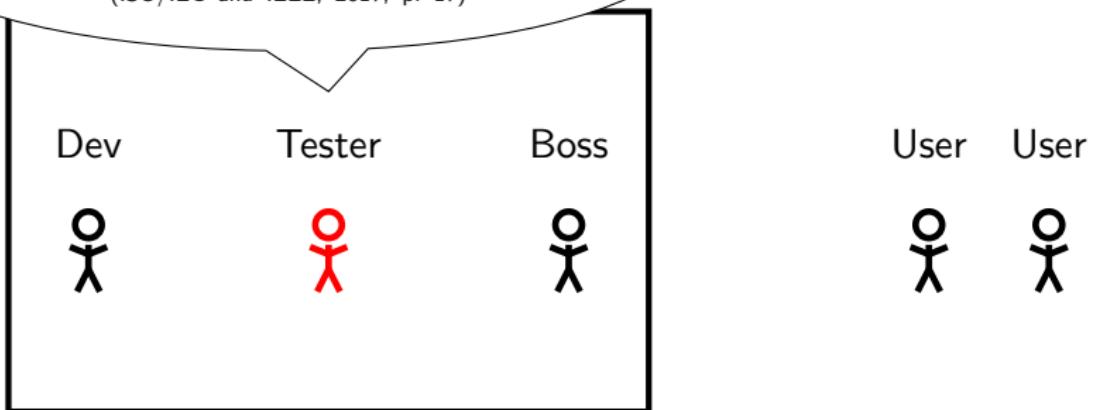


The Lack of Standardized Terminology

"The Problem" (cont.)

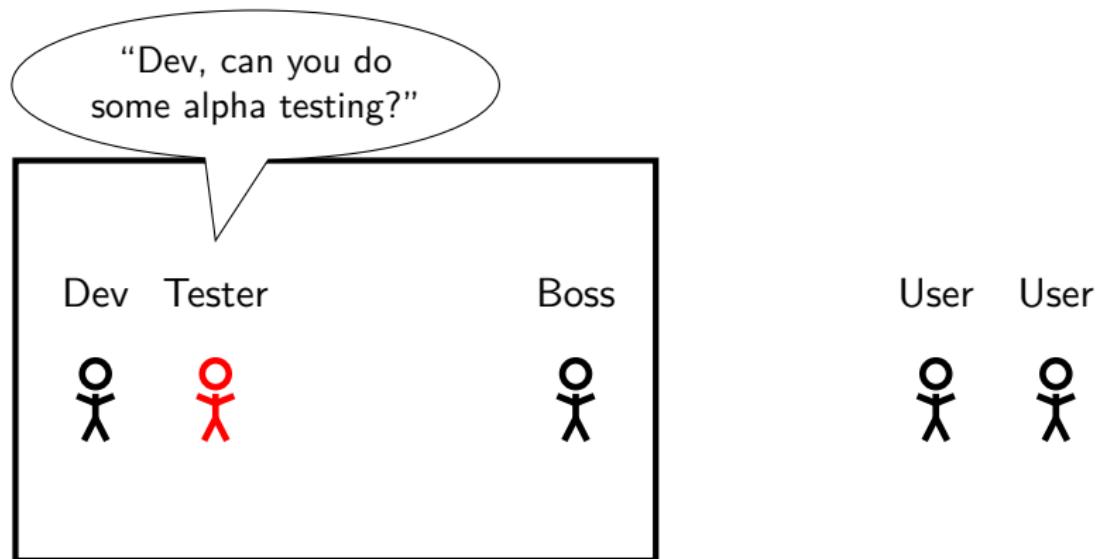
"Alpha testing is done by 'users within the organization developing the software'."

(ISO/IEC and IEEE, 2017, p. 17)



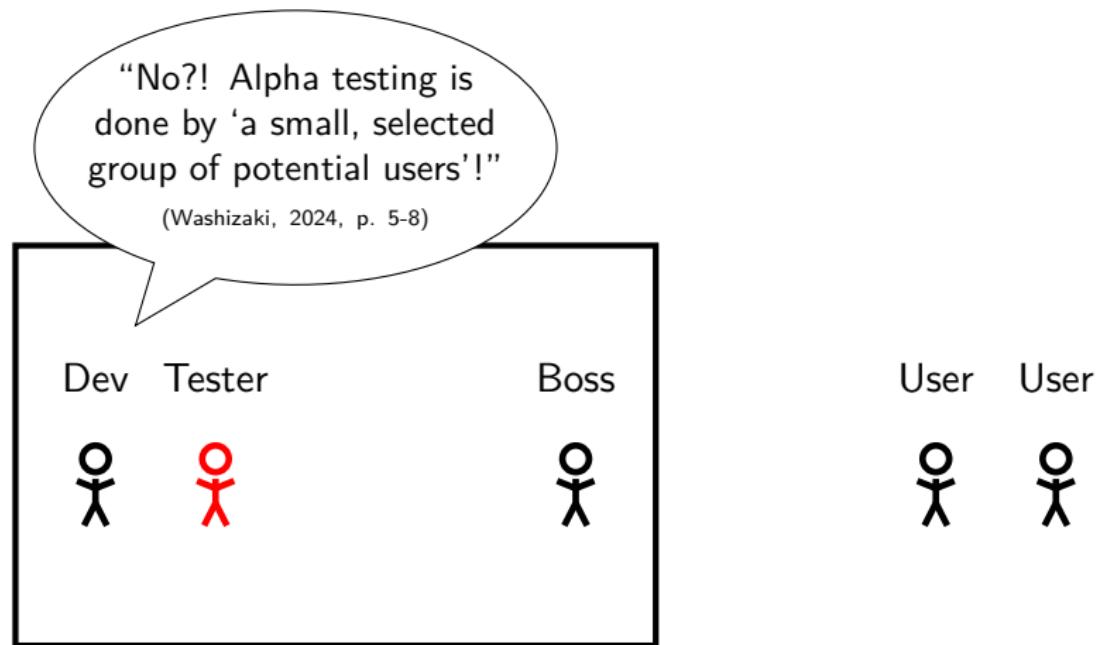
The Lack of Standardized Terminology

"The Problem" (cont.)



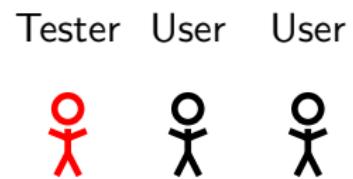
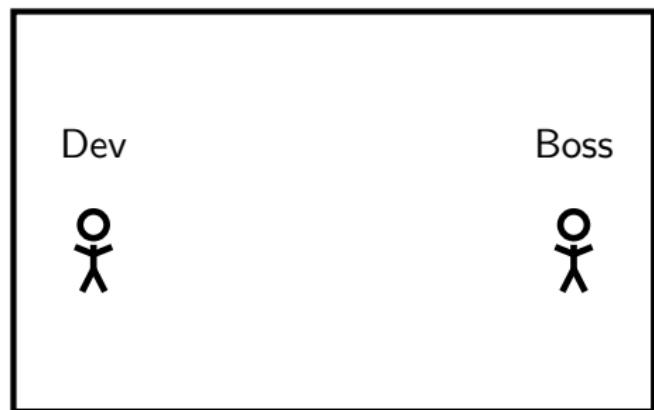
The Lack of Standardized Terminology

"The Problem" (cont.)



The Lack of Standardized Terminology

“The Problem” (cont.)



The Lack of Standardized Terminology

“The Problem” (cont.)

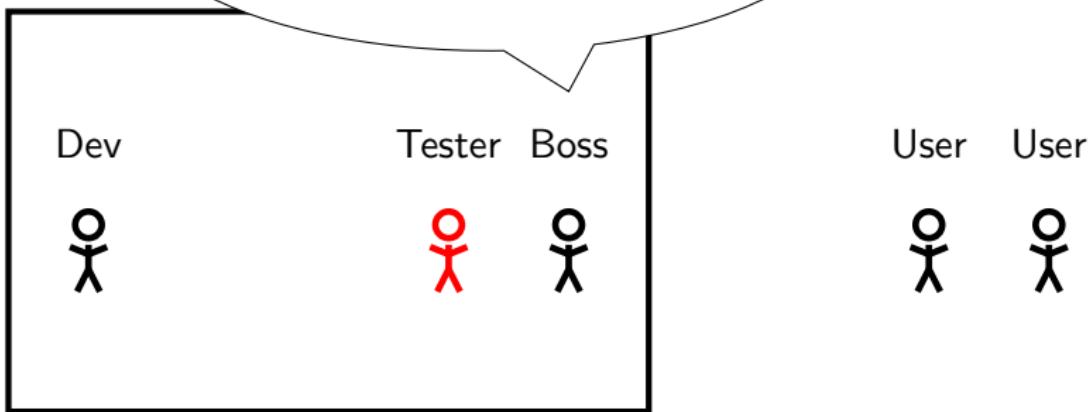


The Lack of Standardized Terminology

“The Problem” (cont.)

“How? Alpha testing is performed
‘in the developer’s test environment’,
but you didn’t bring anyone in.”

(Hamburg and Mogyorodi, 2024)



Barriers to Effective Communication

“The Problem” (cont.)

Interorganizational

Schools, companies, etc.

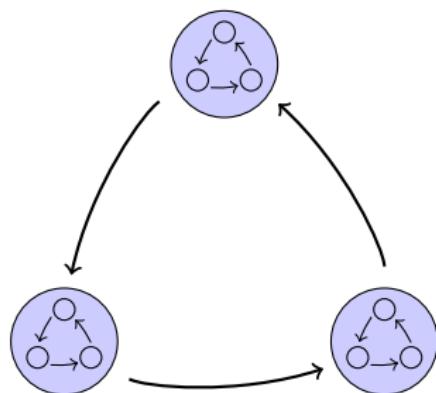


Barriers to Effective Communication

“The Problem” (cont.)

Interorganizational

Schools, companies, etc.



Intraorganizational

“Complete testing” could require the tester to:

- discover every bug,
- exhaust the time allocated,
- implement every planned test,
- . . . (Kaner et al., 2011, p. 7)

Taxonomies to the Rescue?

"The Problem" (cont.)

- Existing software testing taxonomies:

- Tebes et al. (2020)
- Souza et al. (2017)
- Firesmith (2015)
- Unterkalmsteiner et al. (2014)

Focus on:
The Testing Process
Organizing Terminology
Relations between Approaches
Traceability between Stages

Table of Contents

1 Introduction

- The Need for Standardized Terminology
- The Lack of Standardized Terminology

2 Project

- Research Questions
- Methodology

3 Results

Research Questions

Research Question 1

What test approaches do the literature describe?

Research Question 2

How consistent are these descriptions?

Research Question 3

Can we systematically resolve any of these inconsistencies?

Methodology

Procedure

Research Question 1

What test approaches do the literature describe?

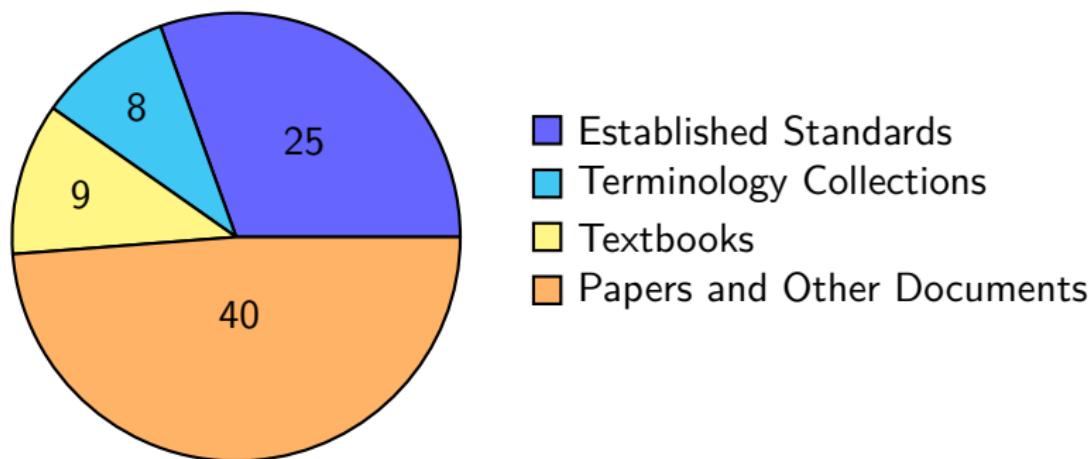
- ① Identify authoritative sources on software testing
- ② Identify all test approaches and testing-related terms
- ③ Record data for these terms; test approach data are comprised of:

| | | |
|--------------|---------------|-----------|
| ① Names | ③ Definitions | ⑤ Parents |
| ② Categories | ④ Synonyms | ⑥ Flaws |
- ④ Repeat steps 1 to 3 for any missing or unclear terms

Methodology

Sources

In total, we investigate 82 sources

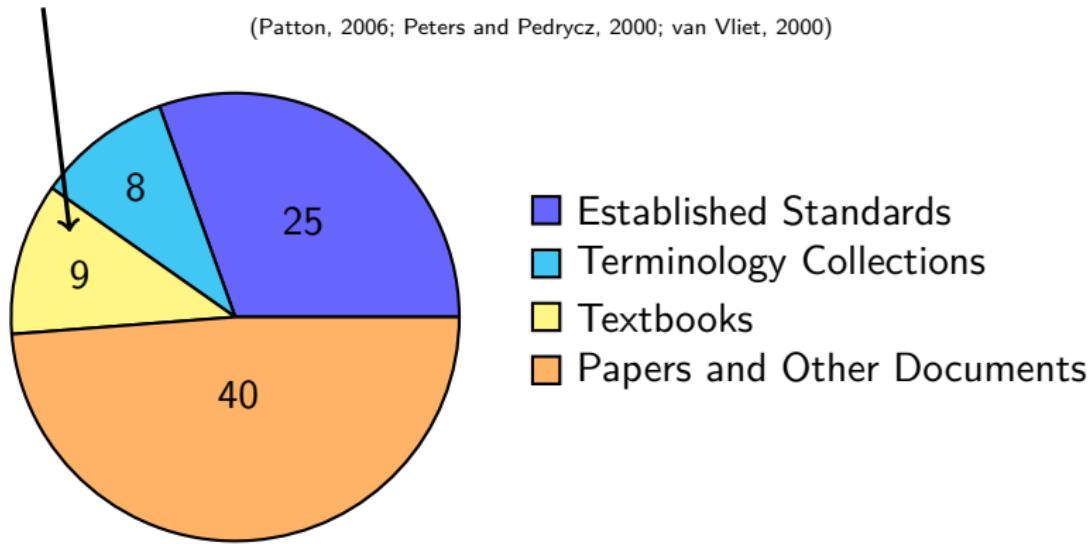


Methodology

Sources

Textbooks used at McMaster were our ad hoc starting points

(Patton, 2006; Peters and Pedrycz, 2000; van Vliet, 2000)



Methodology

Terms

- We build a glossary with a row for each test approach

| Name | Category | Definition | Parent(s) | Synonym(s) |
|-------------|----------------------|---|--|----------------------------------|
| A/B Testing | Practice (Fig. 2) | Testing “that allows testers to determine which of two systems or components performs better” (pp. 1, 36) | Statistical Testing (pp. 1, 36), ... | Split-Run Testing (pp. 1, 36) |

Information from (ISO/IEC and IEEE, 2022)

- We gather this information from sources by looking for:
 - Glossaries, taxonomies, hierarchies, etc.
 - Testing-related terms
 - Terms described *by* other approaches
 - Terms that *imply* other approaches

Methodology

Procedure

Research Question 2

How consistent are these descriptions?

- ⑤ Automatically analyze recorded test approach data
 - ① Visualize approach relations
 - ② Detect certain classes of flaws
 - ③ Analyze manually recorded flaws from step 3.6
- ⑥ Report results of flaw analysis

Research Question 3

Can we systematically resolve any of these inconsistencies?

- ⑦ Provide examples of how to resolve these flaws

Methodology

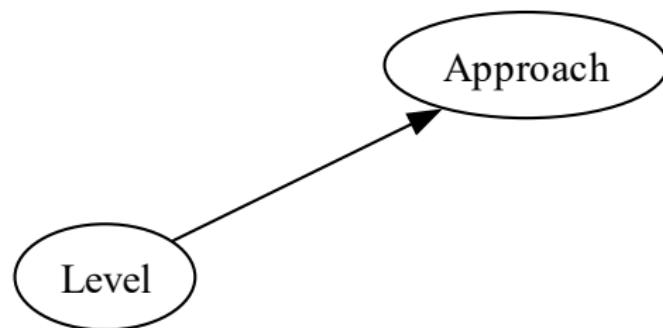
Categories

Approach

Approach: a “high-level test implementation choice” (ISO/IEC and IEEE, 2022, p. 10) used to “pick the particular test case values” (2017, p. 465)

Methodology

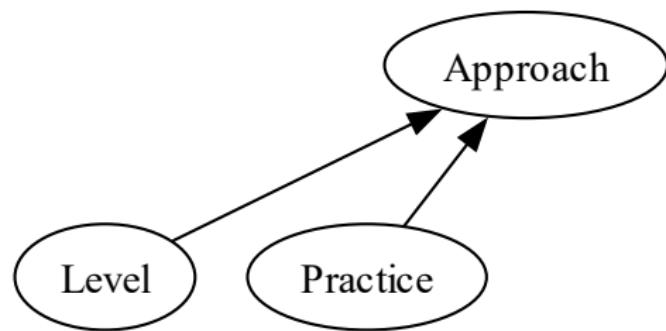
Categories



Level: a stage of testing with “particular objectives and . . . risks”, each performed in sequence (ISO/IEC and IEEE, 2022, p. 12; 2021a, p. 6; 2021c, p. 6)

Methodology

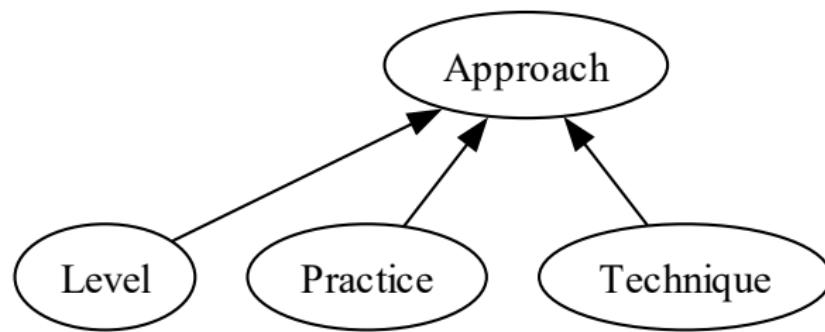
Categories



Practice: a “conceptual framework that can be applied to . . . [a] test process to facilitate testing” (ISO/IEC and IEEE, 2022, p. 14; 2017, p. 471)

Methodology

Categories



Technique: a “procedure used to create or select a test model, identify test coverage items, and derive corresponding test cases” (2022, p. 11; 2021a, p. 5; similar in 2017, p. 467)

Methodology

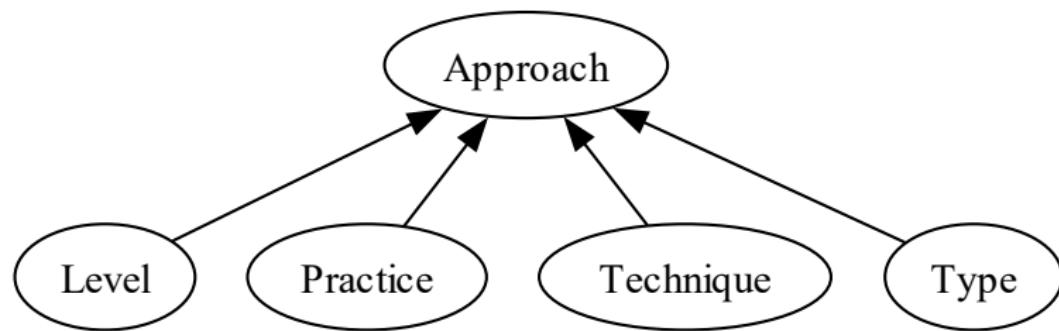
Categories



Type: “testing that is focused on specific quality characteristics”
(ISO/IEC and IEEE, 2022, p. 15; 2021c, p. 7; 2017, p. 473)

Methodology

Visualization Notation



Arrows point from a *child* node to a *parent* node.

Methodology

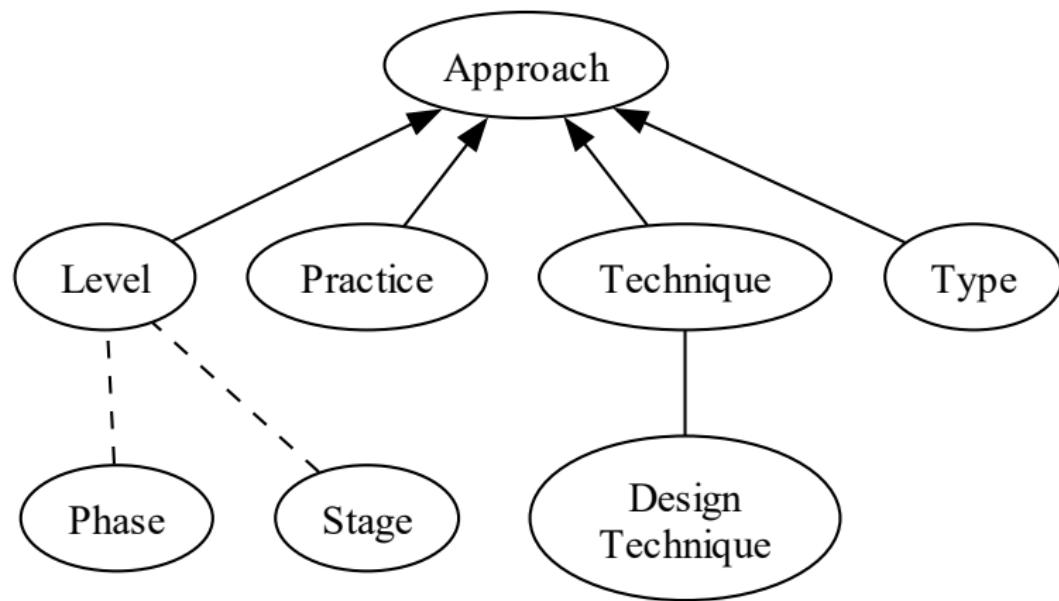
Visualization Notation



Lines without arrowheads connect *synonyms*.

Methodology

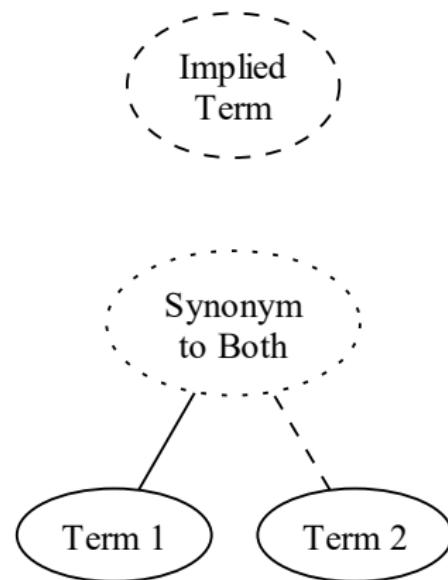
Visualization Notation



Dashed lines indicate a relationship is *implicit*.

Methodology

Visualization Notation



Dashed outlines indicate a term is *implicit*.

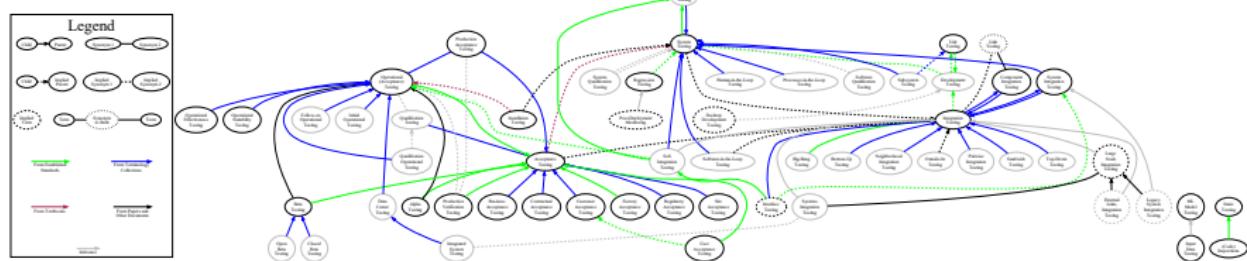
Dotted outlines indicate a term is a *synonym* to more than one term.

Visualization of Test Approaches

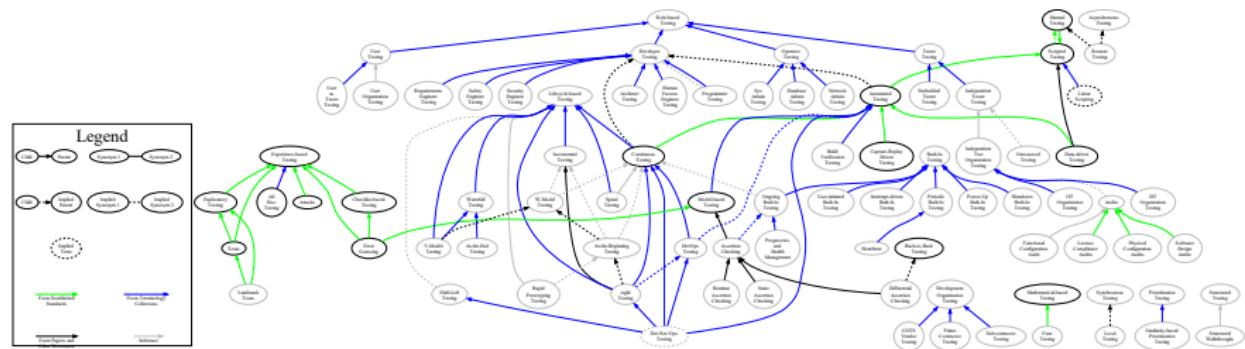
Visualization of Test Approaches

! Dimension too large.

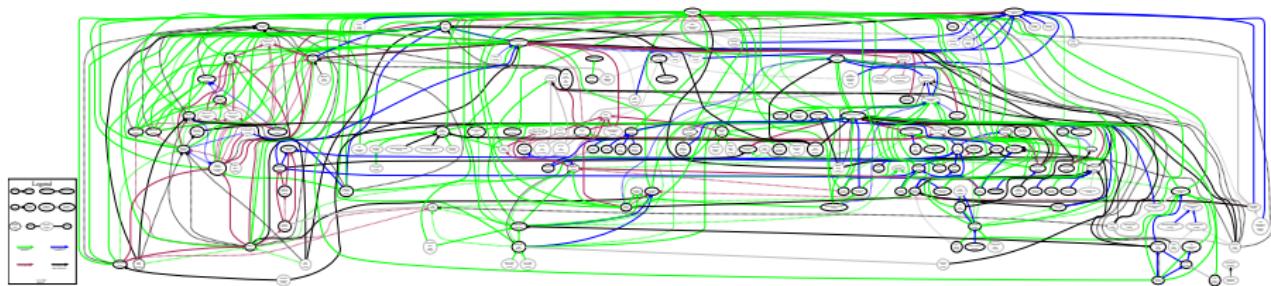
Visualization of Test Levels



Visualization of Test Practices



Visualization of Test Techniques



Visualization of Test Types

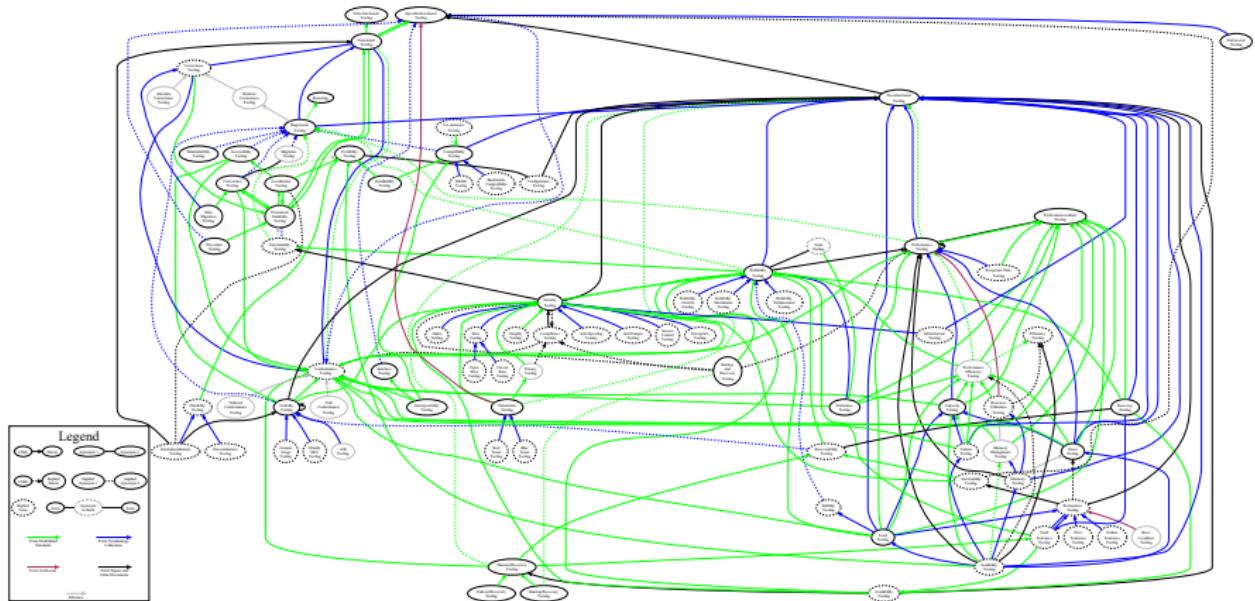


Table of Contents

1 Introduction

- The Need for Standardized Terminology
- The Lack of Standardized Terminology

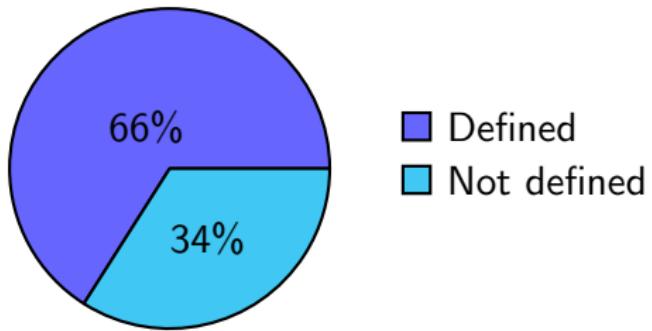
2 Project

- Research Questions
- Methodology

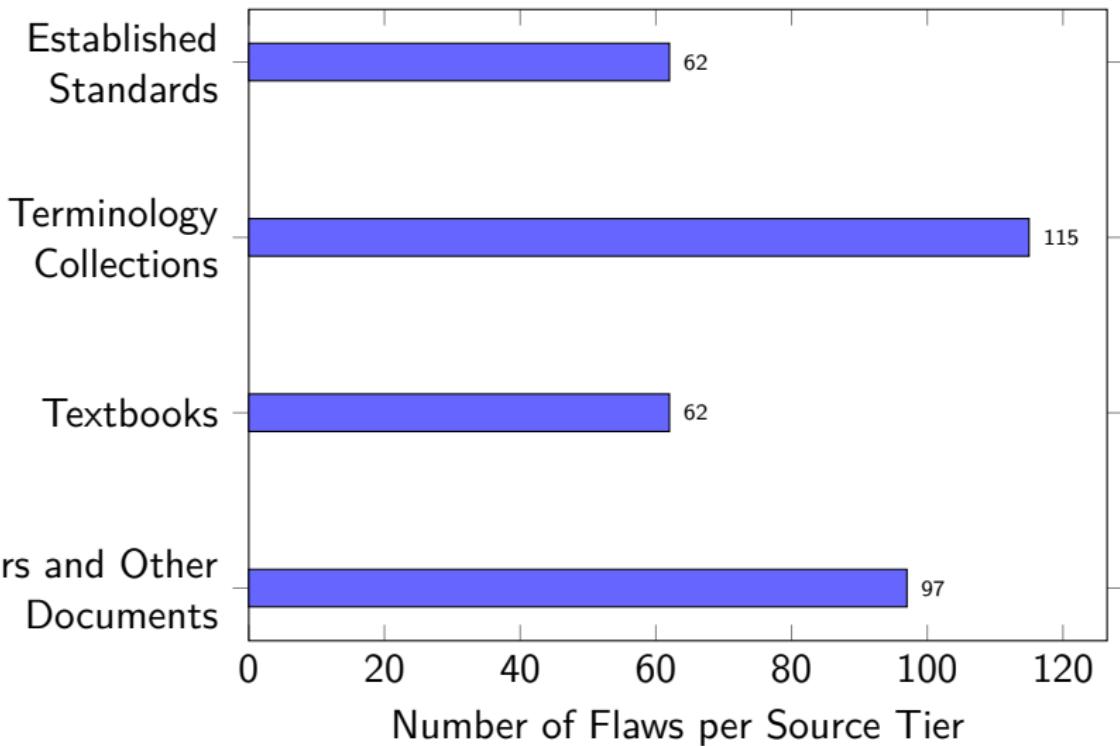
3 Results

Overview

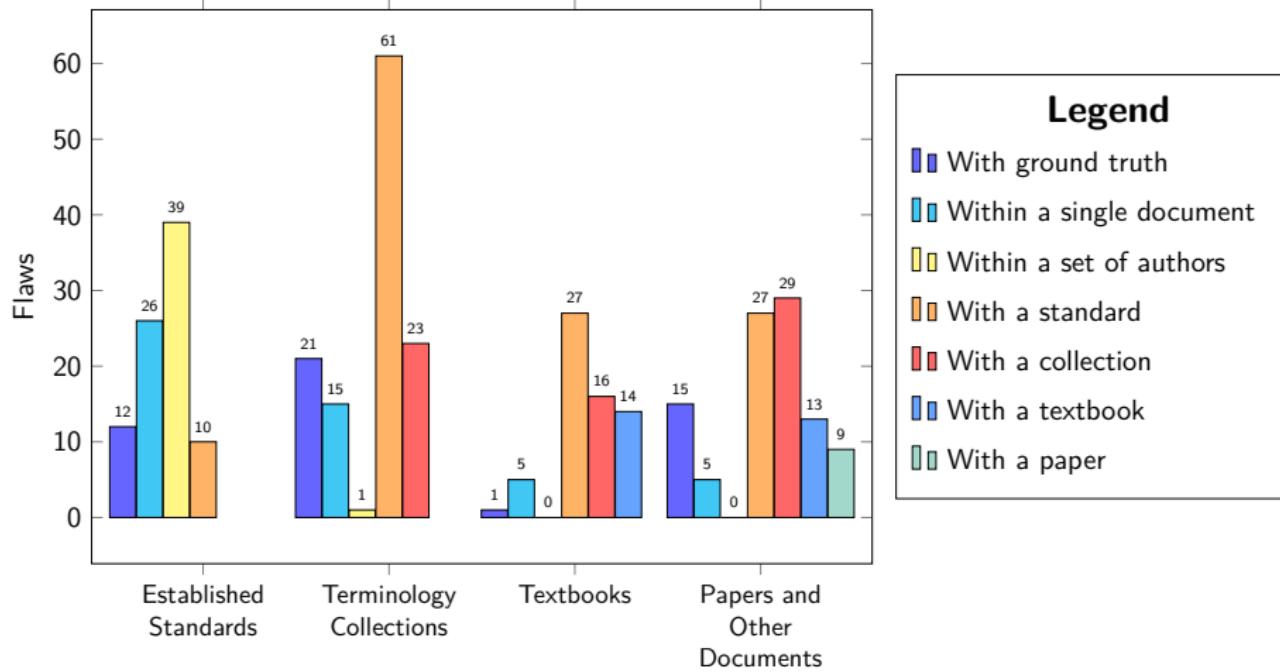
- 564 test approaches →
- 75 software qualities
(may imply test approaches)
- 336 flaws in the software testing literature



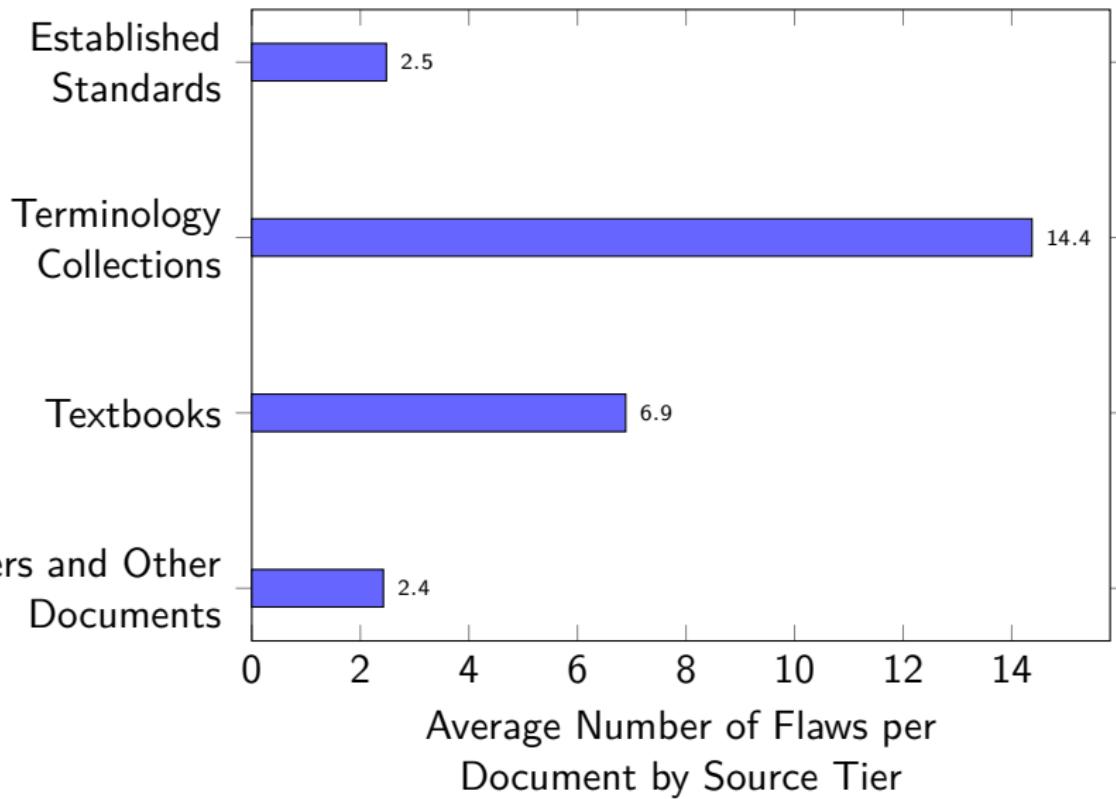
Flaw Summary by Source Tier



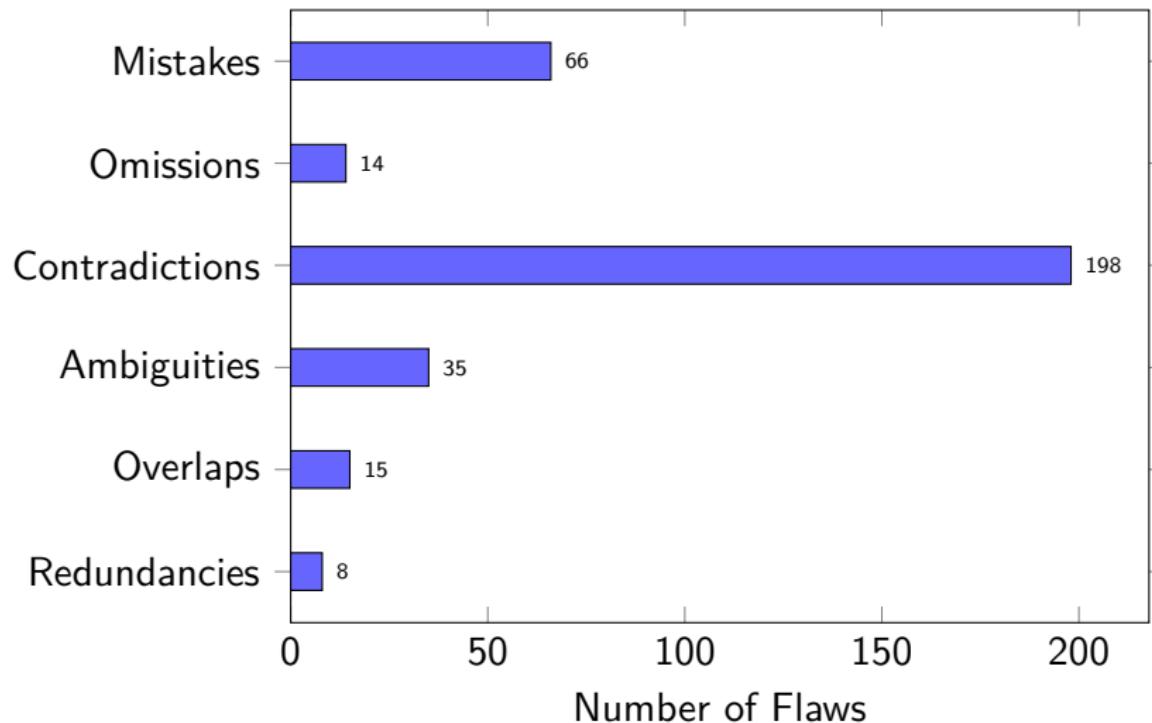
Flaw Summary by Source Tier



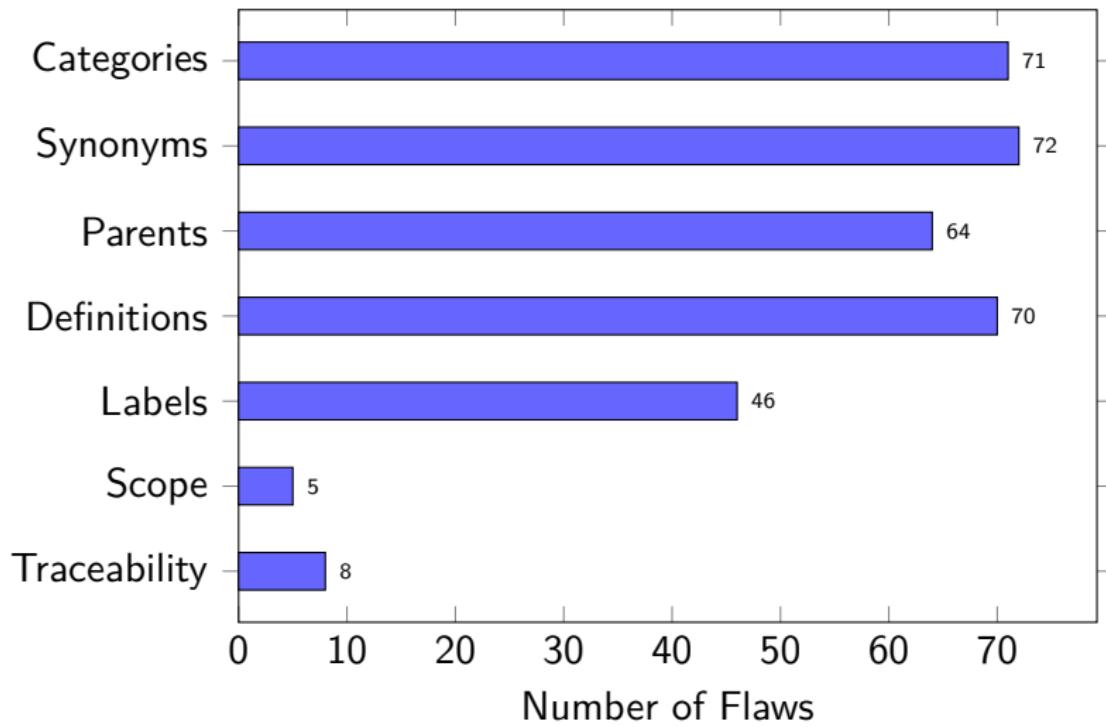
Normalized Flaw Summary



Flaw Summary by Manifestation



Flaw Summary by Domain

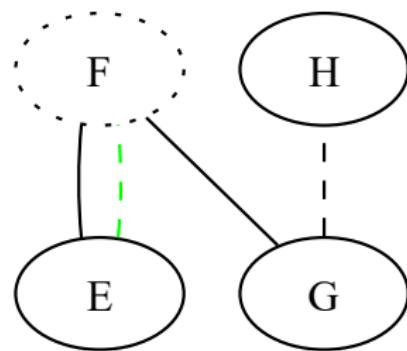


Automated Flaws

Intransitive Synonyms

Some terms are given as a synonym to two (or more) disjoint terms, making their relations ambiguous

| Name | Synonym(s) |
|------|--|
| E | F (Author, 2022; implied by StdAuthor, 2021) |
| G | F (Author, 2017), H (implied by 2022) |
| H | X (StdAuthor, 2021) |



Automated Flaws

Intransitive Synonyms

Some prominent examples:

① Functional Testing:

- Specification-based Testing
- *Conformance Testing*
- *Correctness Testing*

Source(s)

(ISO/IEC and IEEE, 2017, p. 196; ...)

(Washizaki, 2025a, p. 5-7)

(Washizaki, 2025a, p. 5-7)

Automated Flaws

Intransitive Synonyms

Some prominent examples:

① Functional Testing:

- Specification-based Testing
- *Conformance Testing*
- *Correctness Testing*

Source(s)

- (ISO/IEC and IEEE, 2017, p. 196; ...)
(Washizaki, 2025a, p. 5-7)
(Washizaki, 2025a, p. 5-7)

② Portability Testing:

- Flexibility Testing
- Configuration Testing

- (ISO/IEC, 2023)
(Kam, 2008, p. 43)

③ Soak Testing:

- Endurance Testing
- Reliability Testing

- (ISO/IEC and IEEE, 2021c, p. 39)
(Gerrard, 2000a, Tab. 2; 2000b, Tab. 1, p. 26)

Automated Flaws

Irreflexive Parents

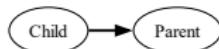
We also find some test approaches that are given as parents of themselves:

- ① Performance Testing (Gerrard, 2000a, Tab. 2; 2000b, Tab. 1)
- ② System Testing (Firesmith, 2015, p. 23)
- ③ Usability Testing (Gerrard, 2000a, Tab. 2; 2000b, Tab. 1)

Automated Flaws

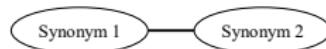
Synonym and Parent-Child Overlaps

Legend



From Established Standards

From Terminology Collections



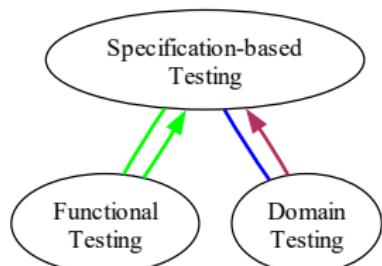
From Textbooks

From Papers and Other Documents



Automated Flaws

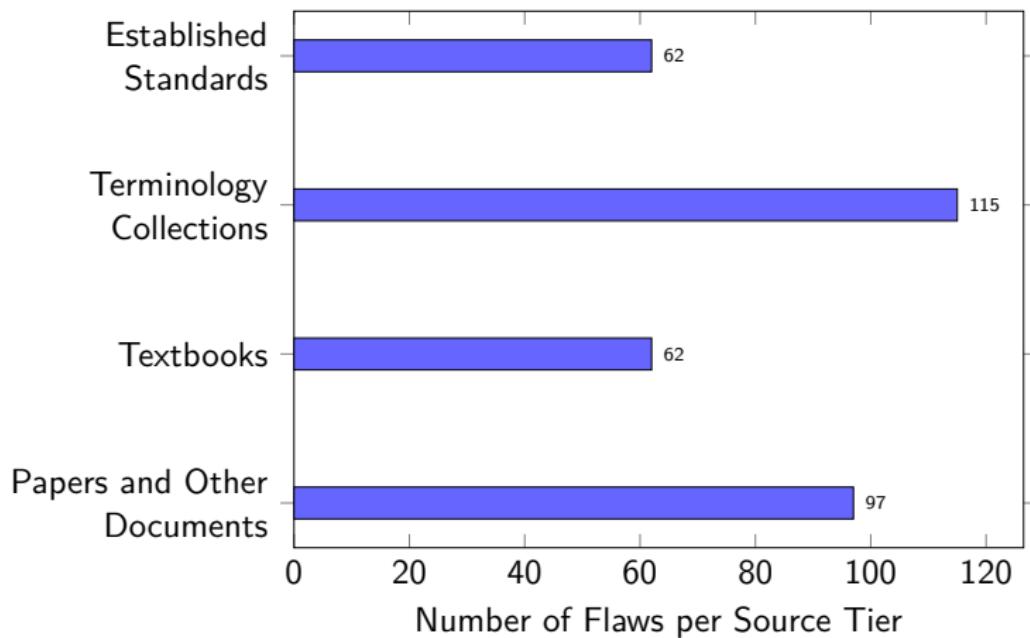
Synonym and Parent-Child Overlaps



- Functional testing is a:
 - Synonym (ISO/IEC and IEEE, 2017, p. 196;
van Vliet, 2000, p. 399; Kam, 2008, pp. 44–45, 48; ...)
 - Child (ISO/IEC and IEEE, 2021c, p. 38; Kam, 2008, p. 42)
- Domain testing is a:
 - Synonym (Washizaki, 2024, p. 5-10)
 - Child (Peters and Pedrycz, 2000, Tab. 12.1)

Conclusion

- The software testing literature is flawed, so don't assume everyone is on the same page



Conclusion

- The software testing literature is flawed, so don't assume everyone is on the same page
- Even if they are, there can still be issues!

What: by Object Under Test (OUT) – System Testing



(Firesmith, 2015, p. 23)

Acknowledgment

- Dr. Spencer Smith and Dr. Jacques Carette have been great supervisors and valuable sources of guidance and feedback
- The format of this presentation was *heavily* based on a previous presentation by Jason Balaci, who also provided a great thesis template
- ChatGPT was used to help generate supplementary Python code for constructing visualizations and generating \LaTeX code, including regex
- ChatGPT and GitHub Copilot were both used for assistance with \LaTeX formatting

References I

- AzaToth. Myoglobin 3D structure, February 2008. URL
<https://commons.wikimedia.org/wiki/File:Myoglobin.png>.
- Donald G. Firesmith. A Taxonomy of Testing Types, 2015. URL
<https://apps.dtic.mil/sti/pdfs/AD1147163.pdf>.
- Paul Gerrard. Risk-based E-business Testing - Part 1: Risks and Test Strategy. Technical report, Systeme Evolutif, London, UK, 2000a. URL
https://www.agileconnection.com/sites/default/files/article/file/2013/XUS129342file1_0.pdf.
- Paul Gerrard. Risk-based E-business Testing - Part 2: Test Techniques and Tools. Technical report, Systeme Evolutif, London, UK, 2000b. URL
wenku.uml.com/document/test/EBTestingPart2.pdf.
- Matthias Hamburg and Gary Mogyorodi, editors. ISTQB Glossary, v4.3, 2024. URL https://glossary.istqb.org/en_US/search.

References II

- ISO/IEC. ISO/IEC 25010:2023 - Systems and software engineering –Systems and software Quality Requirements and Evaluation (SQuaRE) –Product quality model. *ISO/IEC 25010:2023*, November 2023. URL <https://www.iso.org/obp/ui/#iso:std:iso-iec:25010:ed-2:v1:en>.
- ISO/IEC and IEEE. ISO/IEC/IEEE International Standard - Systems and software engineering–Vocabulary. *ISO/IEC/IEEE 24765:2017(E)*, September 2017. doi: 10.1109/IEEESTD.2017.8016712.
- ISO/IEC and IEEE. ISO/IEC/IEEE International Standard - Software and systems engineering –Software testing –Part 2: Test processes. *ISO/IEC/IEEE 29119-2:2021(E)*, October 2021a. doi: 10.1109/IEEESTD.2021.9591508.

References III

ISO/IEC and IEEE. ISO/IEC/IEEE International Standard - Software and systems engineering –Software testing –Part 4: Test techniques.

ISO/IEC/IEEE 29119-4:2021(E), October 2021c. doi:
10.1109/IEEESTD.2021.9591574.

ISO/IEC and IEEE. ISO/IEC/IEEE International Standard - Systems and software engineering –Software testing –Part 1: General concepts.

ISO/IEC/IEEE 29119-1:2022(E), January 2022. doi:
10.1109/IEEESTD.2022.9698145.

Ben Kam. Web Applications Testing. Technical Report 2008-550, Queen's University, Kingston, ON, Canada, October 2008. URL <https://research.cs.queensu.ca/TechReports/Reports/2008-550.pdf>.

References IV

- Cem Kaner, James Bach, and Bret Pettichord. *Lessons Learned in Software Testing: A Context-Driven Approach*. John Wiley & Sons, December 2011. ISBN 978-0-471-08112-8. URL <https://www.wiley.com/en-ca/Lessons+Learned+in+Software+Testing%3A+A+Context-Driven+Approach-p-9780471081128>.
- Kjerish. Part of CNO cycle diagram, made just to be illustrative for nuclear reactions in general, December 2016. URL <https://commons.wikimedia.org/wiki/File:NuclearReaction.svg>.
- Ron Patton. *Software Testing*. Sams Publishing, Indianapolis, IN, USA, 2nd edition, 2006. ISBN 0-672-32798-8.
- Penubag and Arnaud Ramey. A few images illustrating forces, August 2010. URL https://commons.wikimedia.org/wiki/File:Force_examples.svg.

References V

J.F. Peters and W. Pedrycz. *Software Engineering: An Engineering Approach*. Worldwide series in computer science. John Wiley & Sons, Ltd., 2000. ISBN 978-0-471-18964-0.

Erica Souza, Ricardo Falbo, and Nandamudi Vijaykumar. ROoST: Reference Ontology on Software Testing. *Applied Ontology*, 12:1–32, March 2017. doi: 10.3233/AO-170177.

Guido Tebes, Luis Olsina, Denis Peppino, and Pablo Becker. TestTDO: A Top-Domain Software Testing Ontology. pages 364–377, Curitiba, Brazil, May 2020. ISBN 978-1-71381-853-3.

Michael Unterkalmsteiner, Robert Feldt, and Tony Gorschek. A Taxonomy for Requirements Engineering and Software Test Alignment. *ACM Transactions on Software Engineering and Methodology*, 23(2):1–38, March 2014. ISSN 1049-331X, 1557-7392. doi: 10.1145/2523088. URL <http://arxiv.org/abs/2307.12477>. arXiv:2307.12477 [cs].

References VI

Hans van Vliet. *Software Engineering: Principles and Practice*. John Wiley & Sons, Ltd., Chichester, England, 2nd edition, 2000. ISBN 0-471-97508-7.

Hironori Washizaki, editor. *Guide to the Software Engineering Body of Knowledge, Version 4.0*. January 2024.

Hironori Washizaki, editor. *Guide to the Software Engineering Body of Knowledge, Version 4.0a*. May 2025a. URL <https://ieeecs-media.computer.org/media/education/swebok/swebok-v4.pdf>.