

Putting Software Testing Terminology to the Test

M.A.Sc. Seminar

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Fall 2024

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1 Introduction

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

2 Project

- Research Questions
- Methodology

3 Results

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The Need for Standardized Terminology

- Engineering is applied science
- Scientific fields use precise terminology



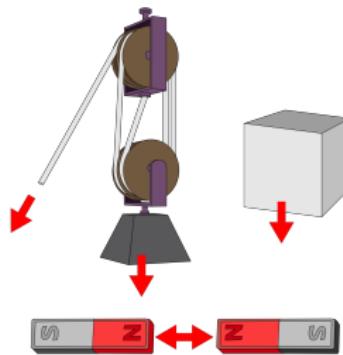
SOFTWARE
ENGINEERING

The Need for Standardized Terminology

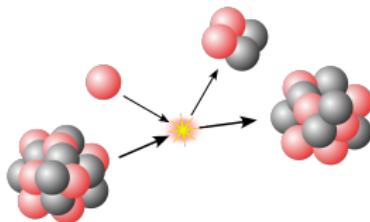
- Engineering is applied science
- Scientific fields use precise terminology



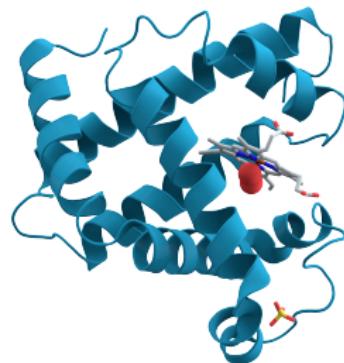
SOFTWARE
ENGINEERING



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"

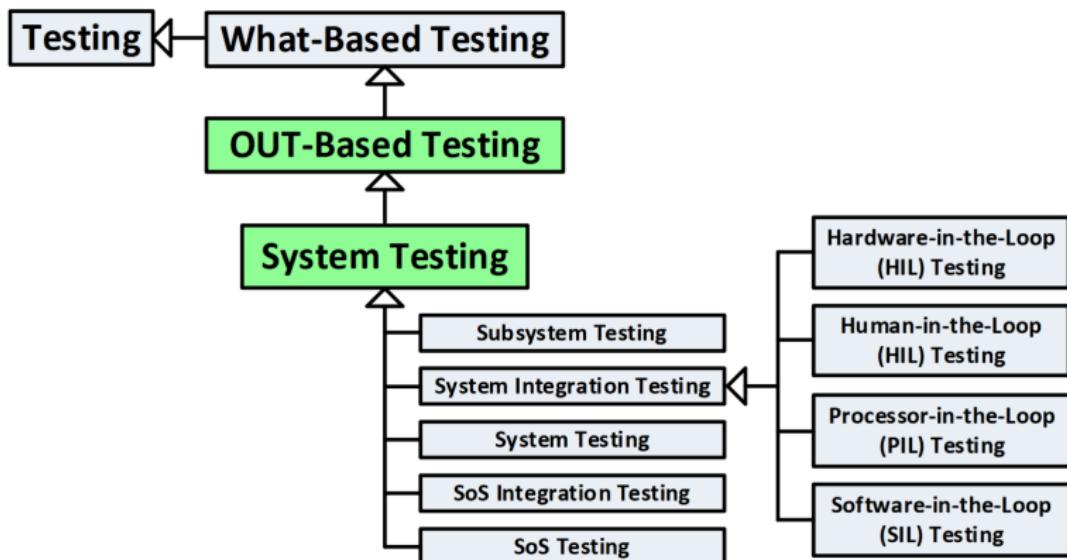


Adapted from (ISO/IEC and IEEE, 2022, Fig. 2)

The Lack of Standardized Terminology

“The Problem” (cont.)

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

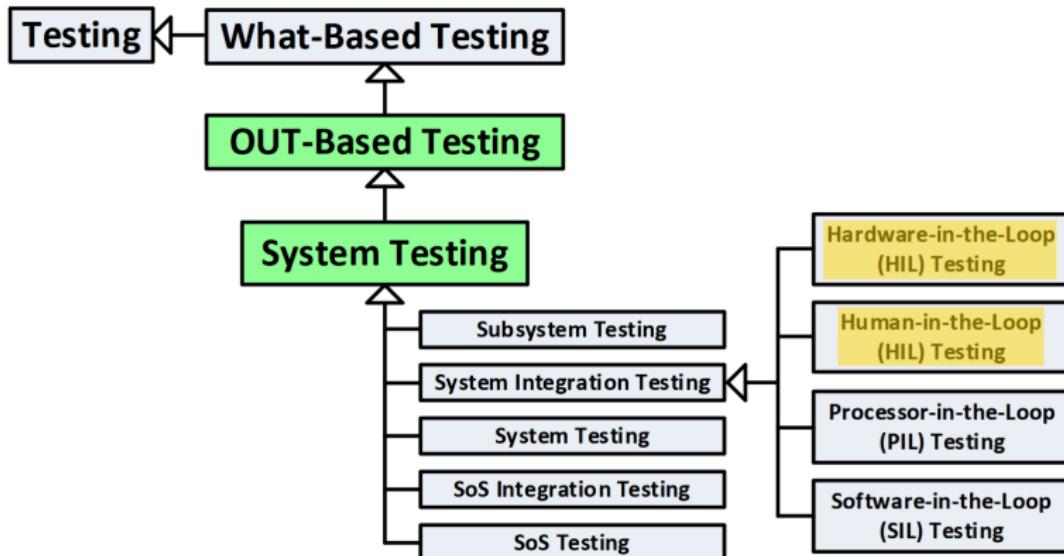


(Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

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

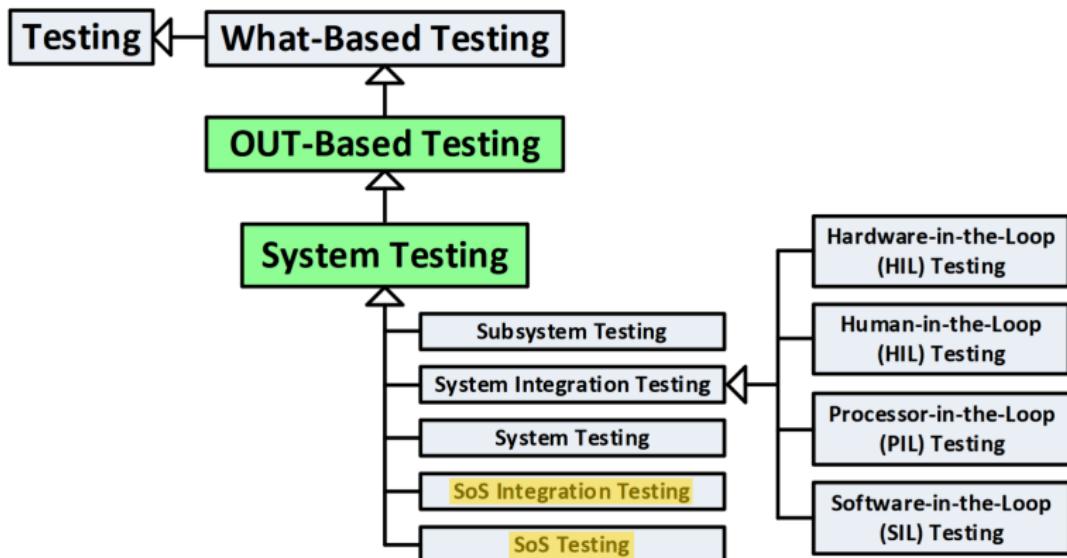


Adapted from (Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

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

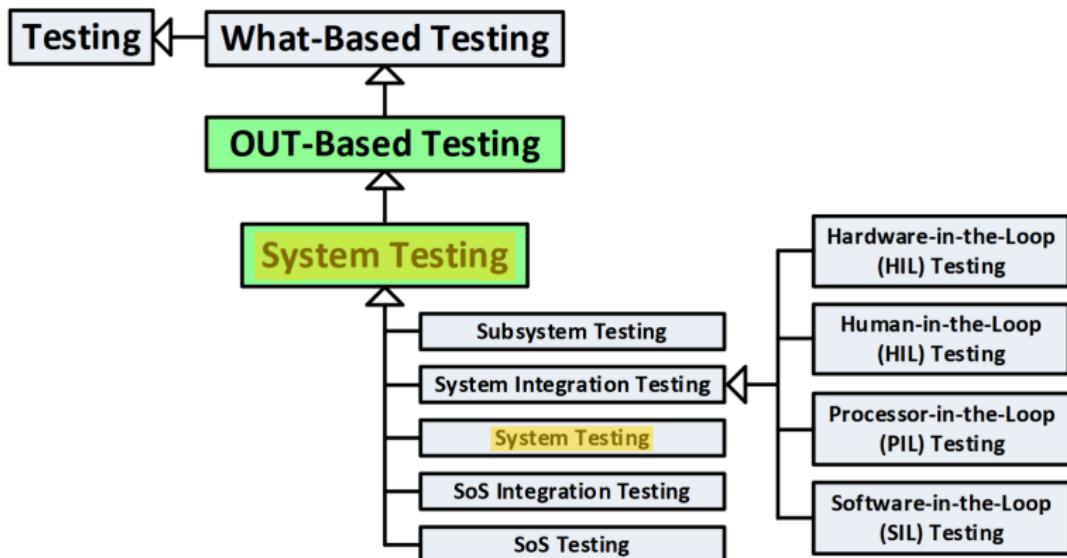


Adapted from (Firesmith, 2015, p. 23)

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.)

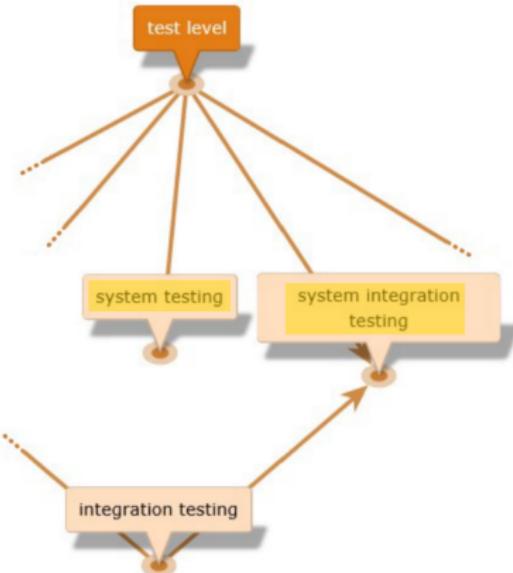
What: by Object Under Test (OUT) – System Testing



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

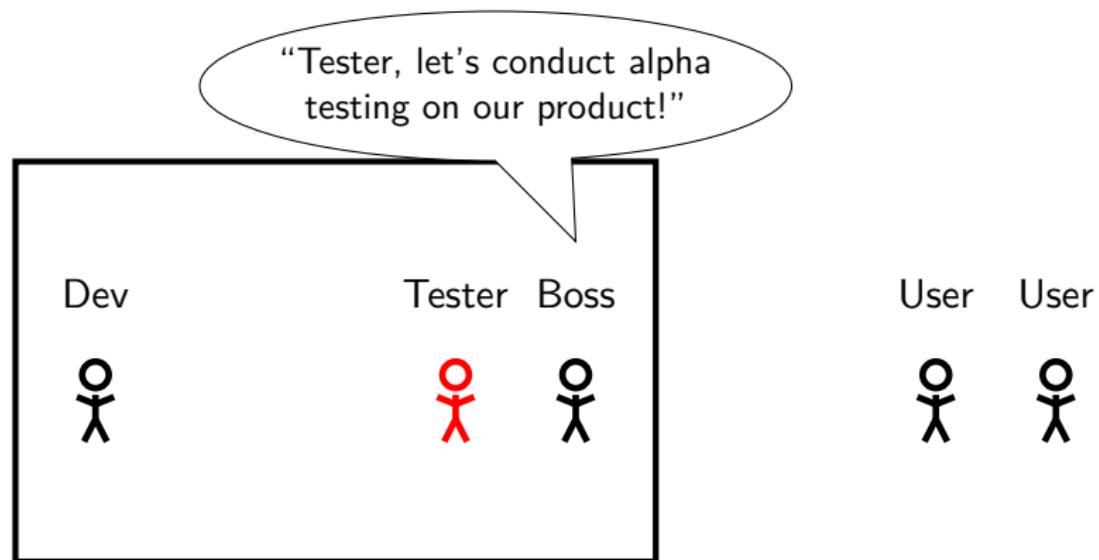
SoS Integration Testing

SoS Testing

Adapted from (Firesmith, 2015, p. 23)

The Lack of Standardized Terminology

“The Problem” (cont.)

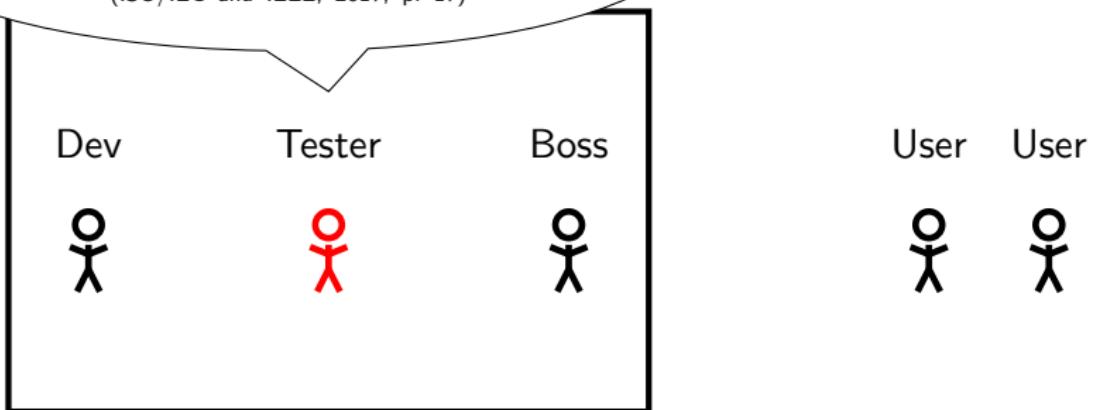


The Lack of Standardized Terminology

"The Problem" (cont.)

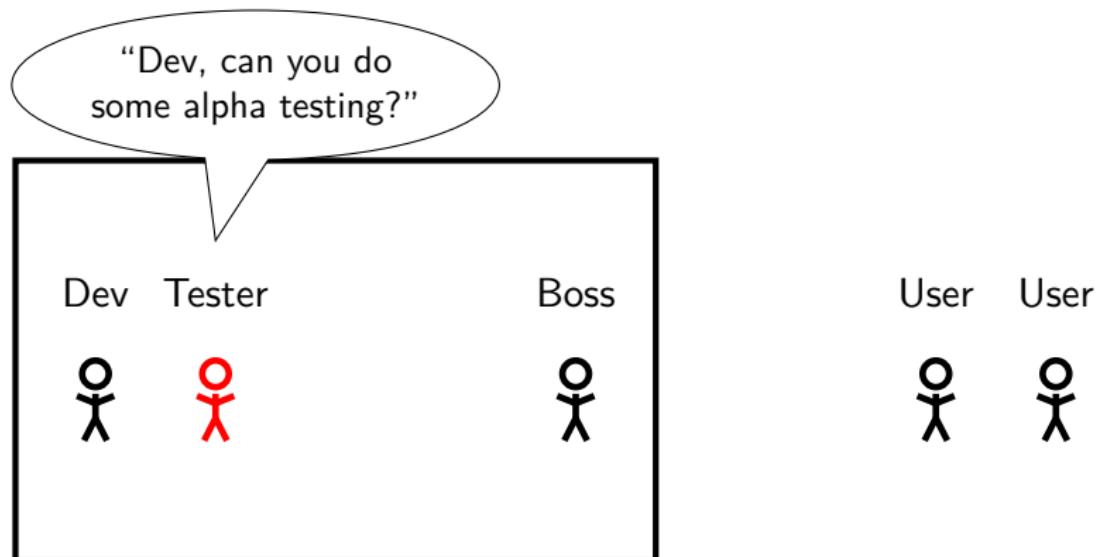
"Alpha testing is done by 'users within the organization developing the software'."

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



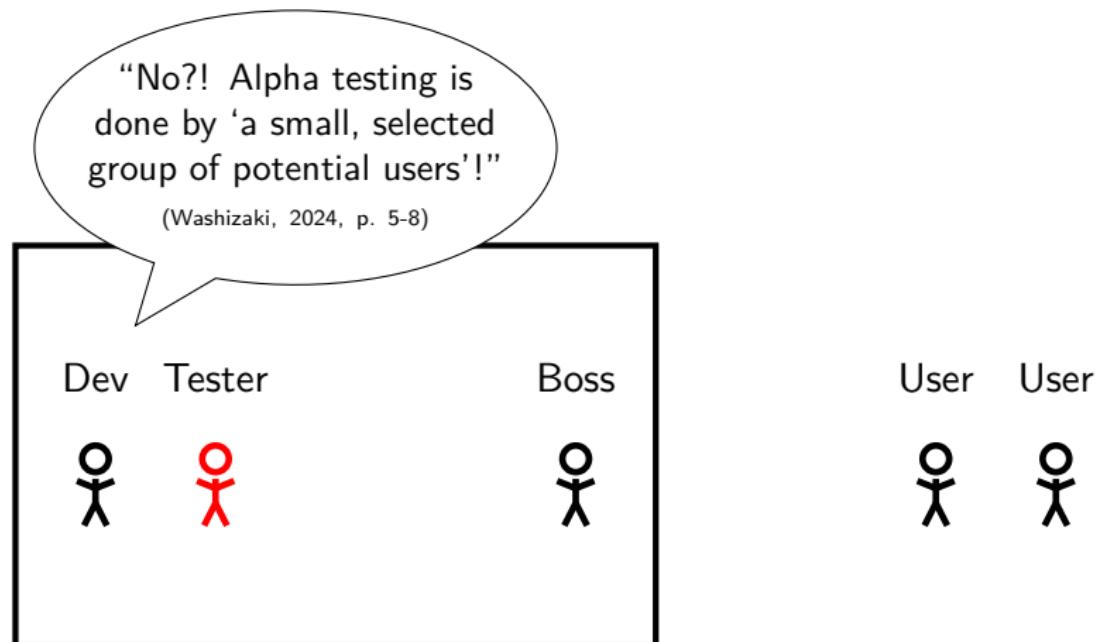
The Lack of Standardized Terminology

“The Problem” (cont.)



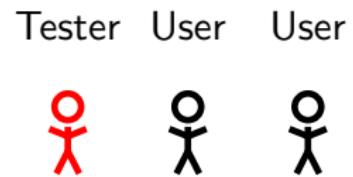
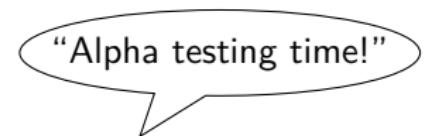
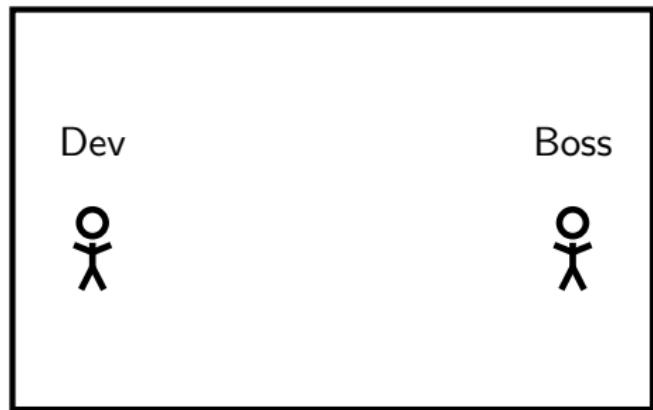
The Lack of Standardized Terminology

"The Problem" (cont.)



The Lack of Standardized Terminology

“The Problem” (cont.)



The Lack of Standardized Terminology

“The Problem” (cont.)

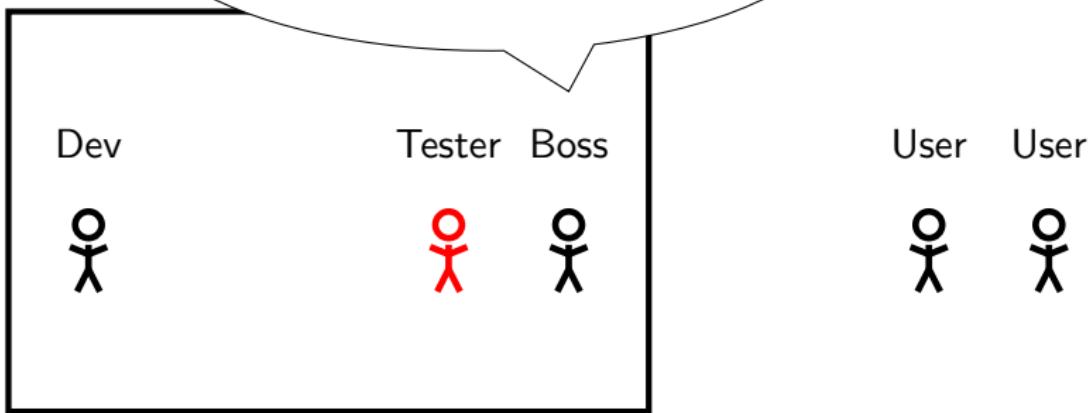


The Lack of Standardized Terminology

“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.

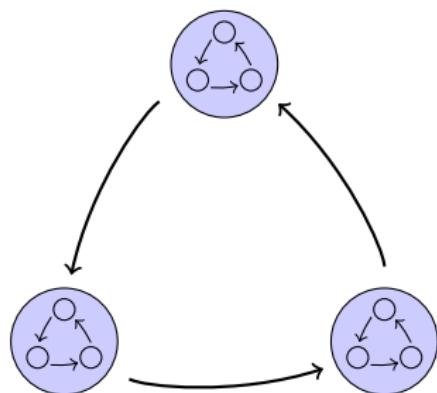


Barriers to Effective Communication

“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

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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?

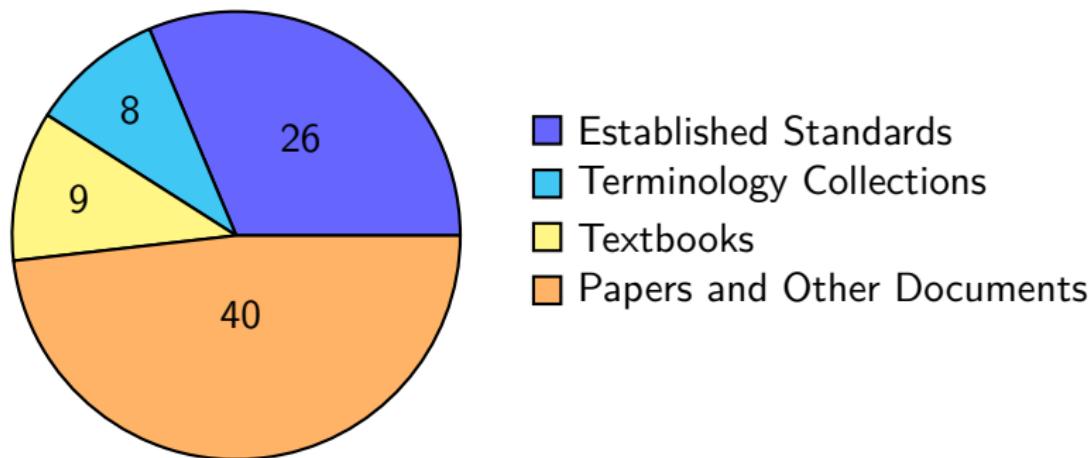
- ① Identify authoritative sources on software testing
- ② Identify all test approaches and testing-related terms
- ③ Record data for these terms; test approach data are comprised of:

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 83 sources

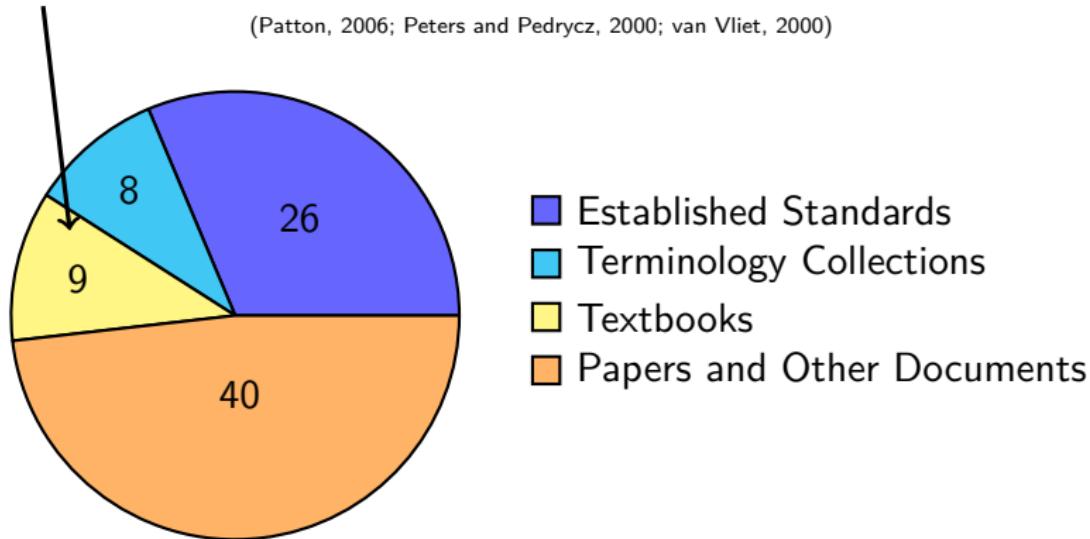


Methodology

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

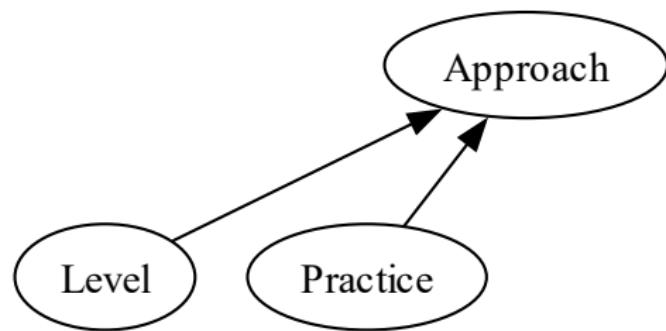
Categories



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

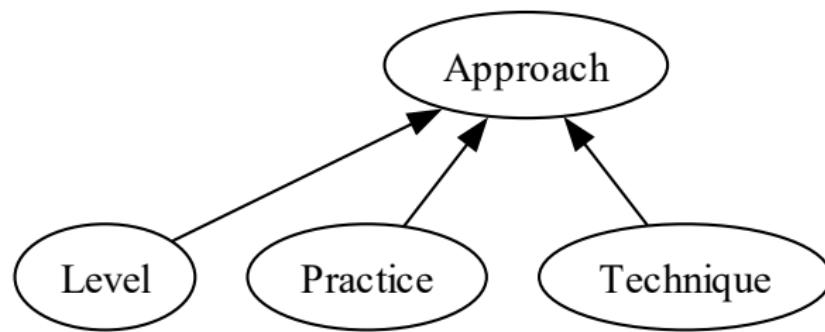
Categories



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

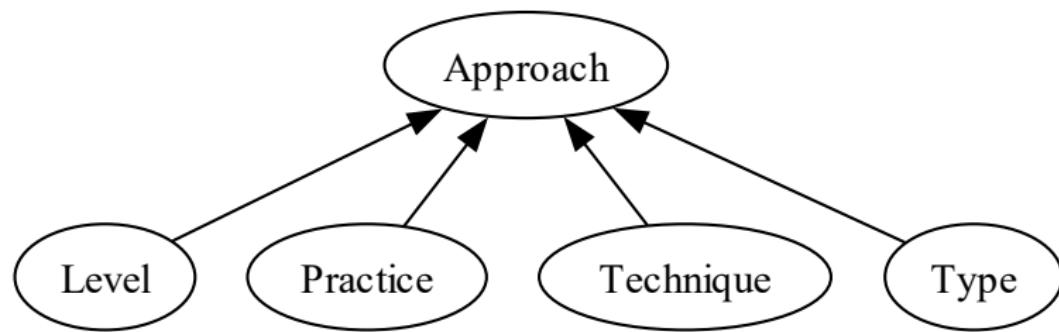
Categories



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

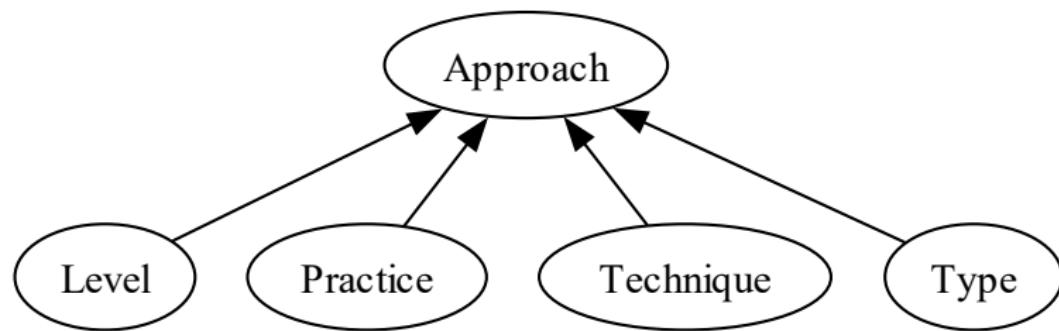
Categories



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

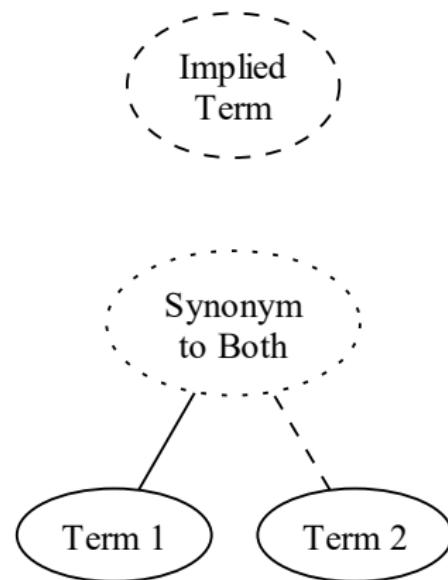
Visualization Notation



Dashed lines indicate a relationship is *implicit*.

Methodology

Visualization Notation



Dashed outlines indicate a term is *implicit*.

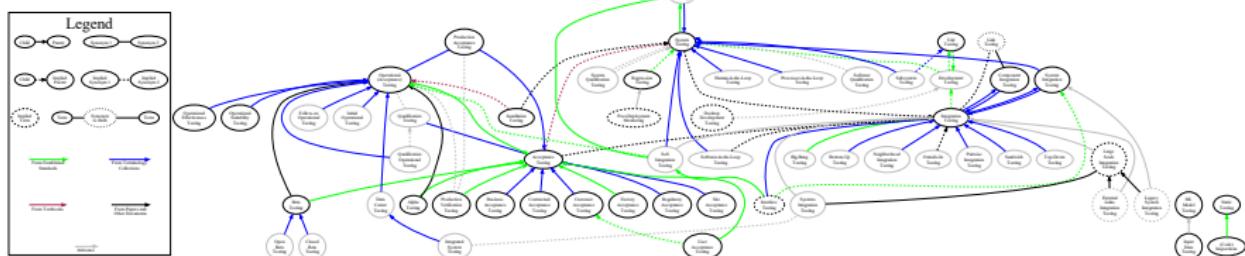
Dotted outlines indicate a term is a *synonym* to more than one term.

Visualization of Test Approaches

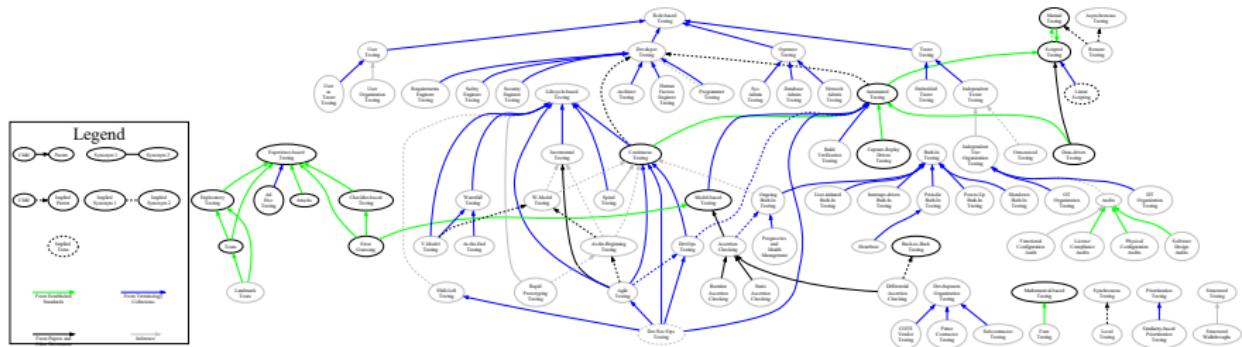
Visualization of Test Approaches

! Dimension too large.

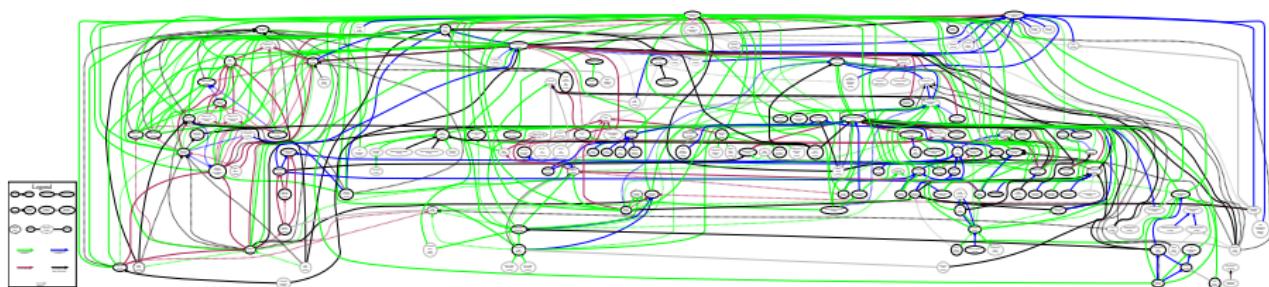
Visualization of Test Levels



Visualization of Test Practices



Visualization of Test Techniques



Visualization of Test Types

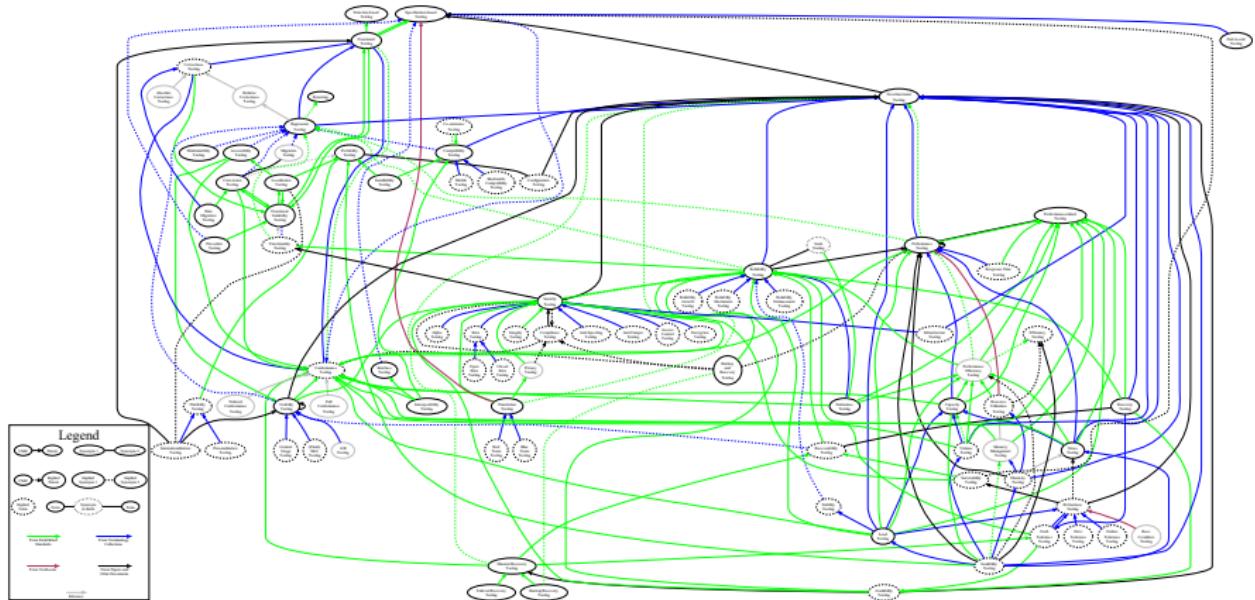


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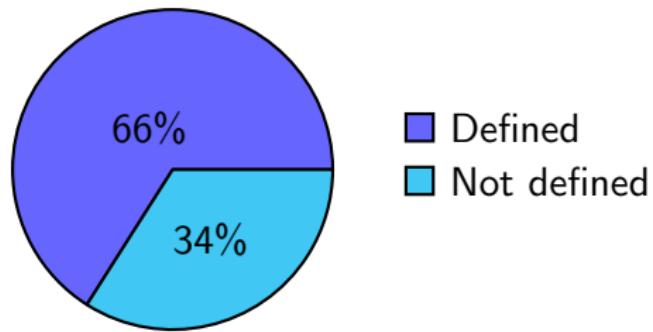
2 Project

- Research Questions
- Methodology

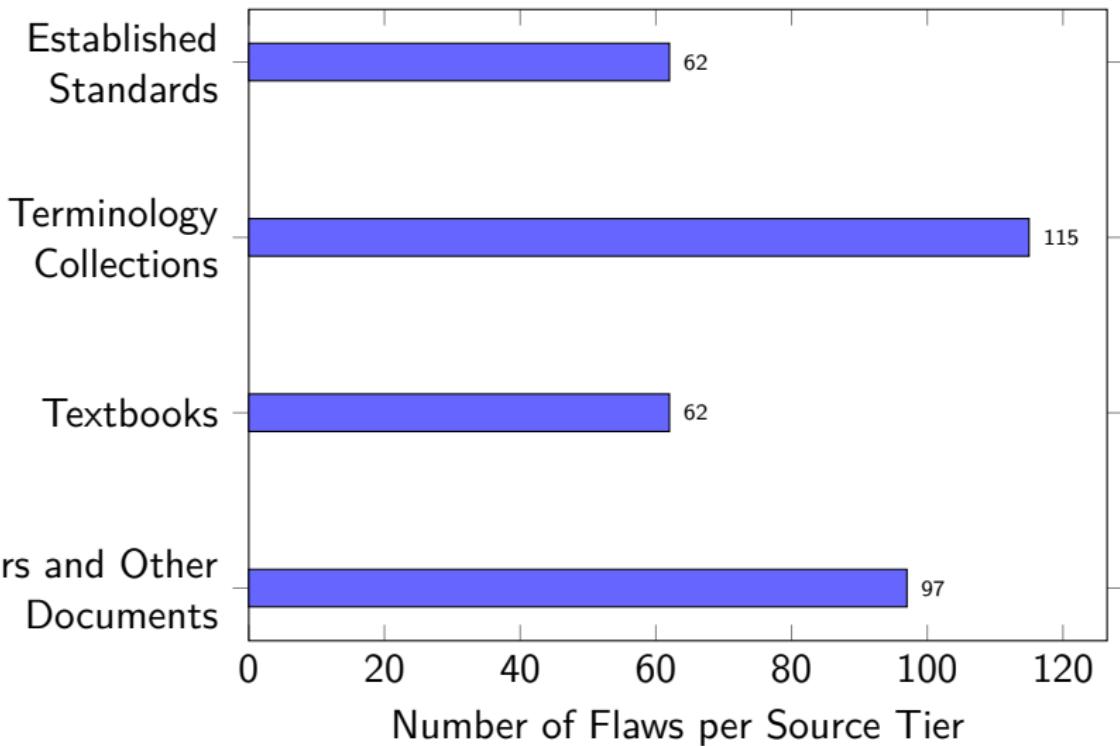
3 Results

Overview

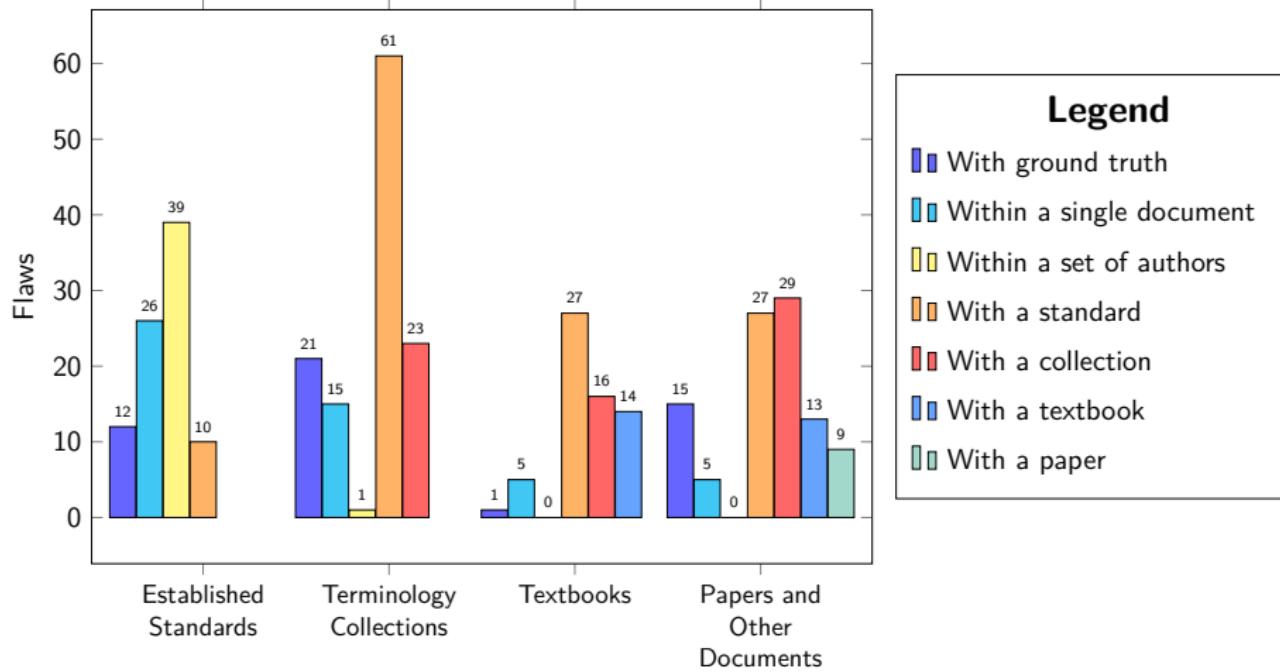
- 564 test approaches →
- 75 software qualities
(may imply test approaches)
- 336 flaws in the software testing literature



Flaw Summary by Source Tier



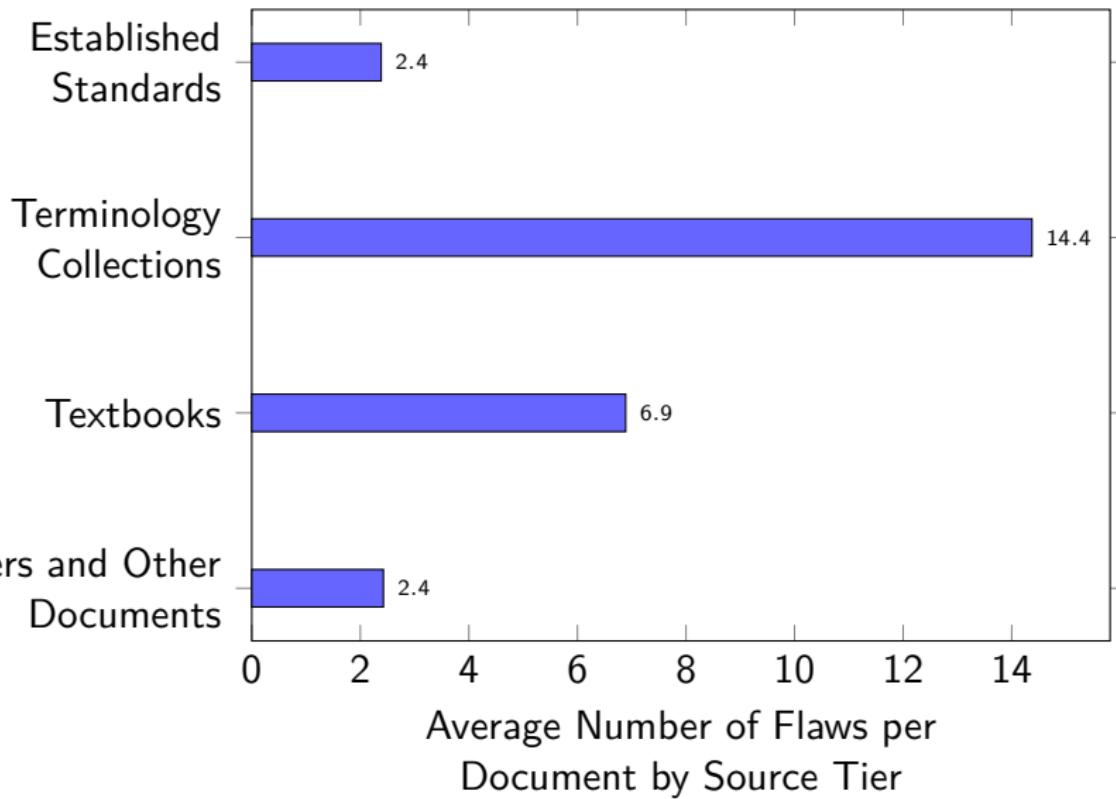
Flaw Summary by Source Tier



Legend

- With ground truth
- Within a single document
- Within a set of authors
- With a standard
- With a collection
- With a textbook
- With a paper

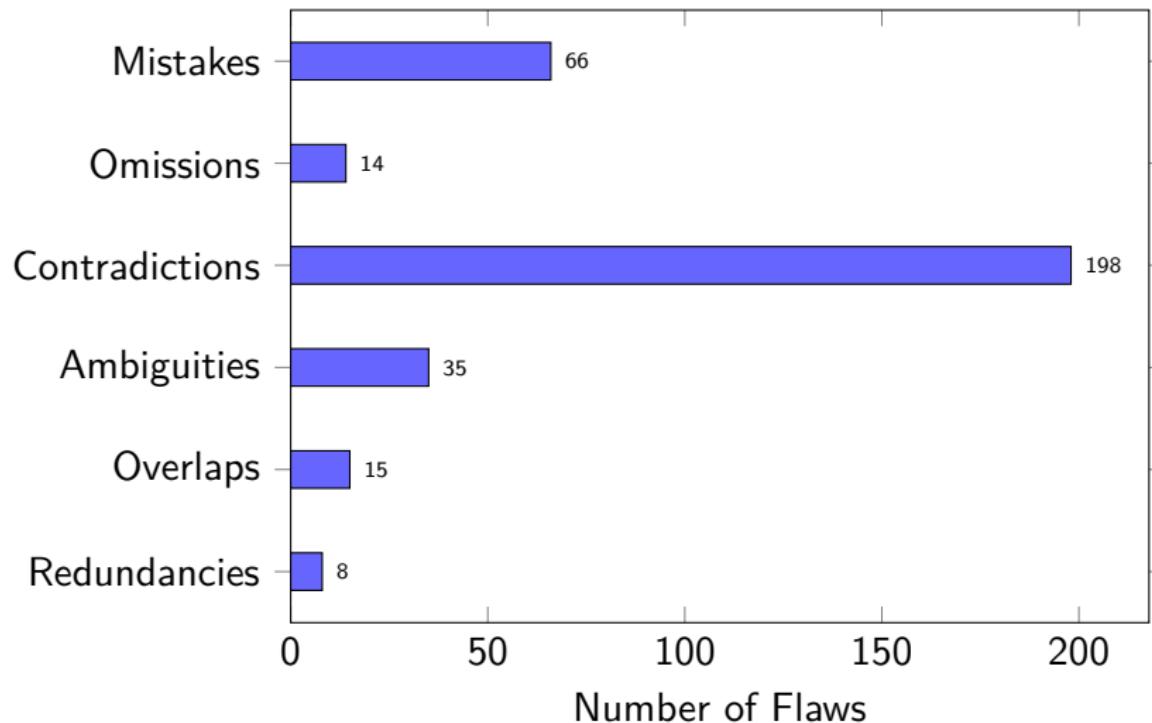
Normalized Flaw Summary



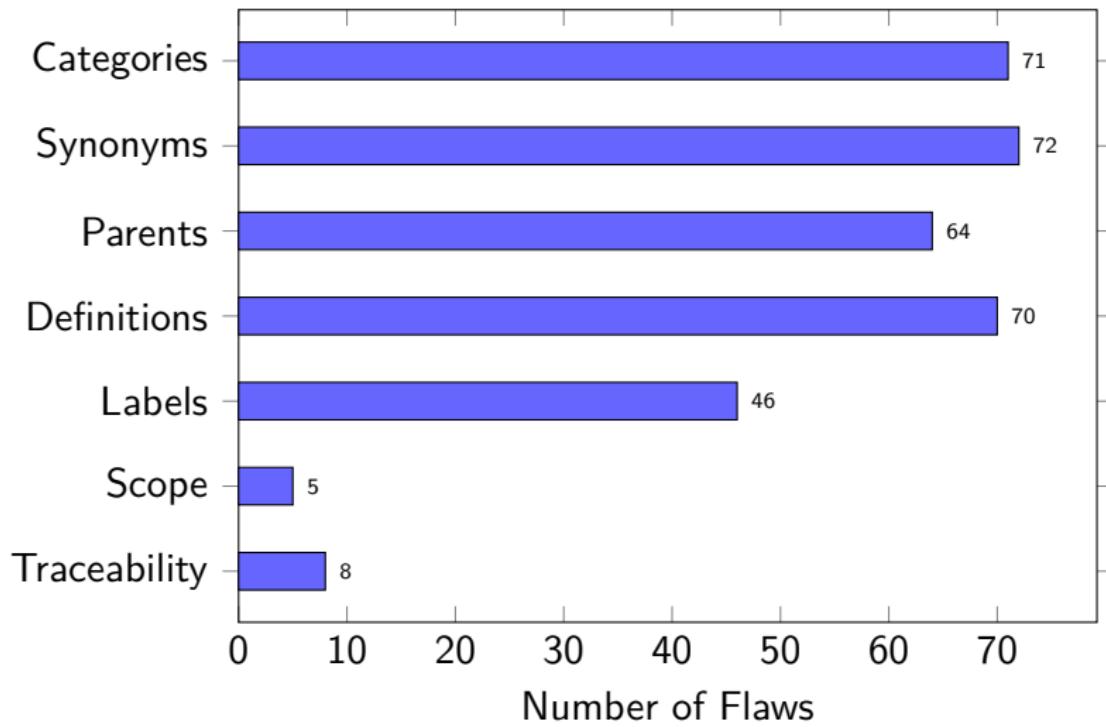
Flaws by Source Tier Observations

- ① Established standards are not actually standardized, since:
 - ① other documents frequently disagree with them and
 - ② they are the most internally inconsistent source tier!
- ② Less standardized documents, such as terminology collections and textbooks, are also not followed to the extent they should be.
- ③ Documents across the board have flaws within the same document, between documents with the same author(s), or even with assertions of ground truth!

Flaw Summary by Manifestation



Flaw Summary by Domain



General Flaw Observations

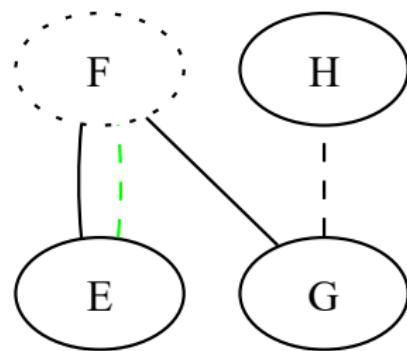
- ① Contradictions are by far the most common manifestation. This is likely because these are the most obvious flaws to detect automatically and because two (sets of) authors using different resources and not communicating have a high chance of disagreeing.
- ② Approach categorizations are the most subjective and one of the most common flaw domains, likely due to the lack of standardization about what categories to use.
- ③ In general, semantic flaws are more common than syntactic ones. The number of category flaws is comparable to the numbers of flaws with the relations and definitions of test approaches.

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

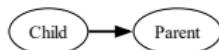
We also find some test approaches that are given as parents of themselves:

- 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

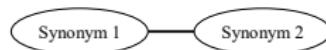
Synonym and Parent-Child Overlaps

Legend



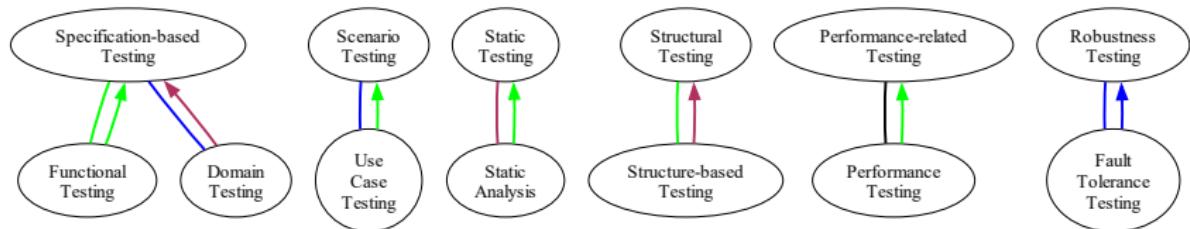
From Established Standards

From Terminology Collections



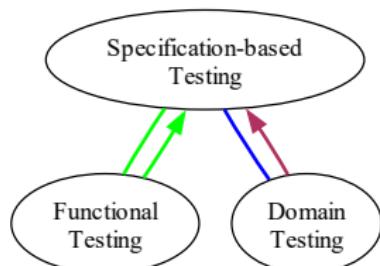
From Textbooks

From Papers and Other Documents



Automated Flaws

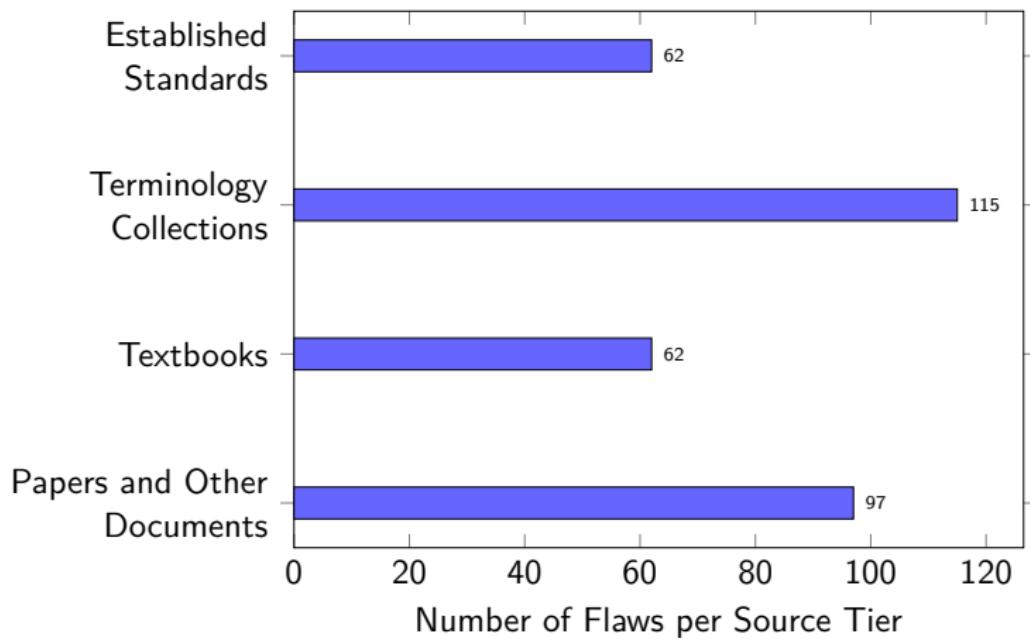
Synonym and Parent-Child Overlaps



- 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

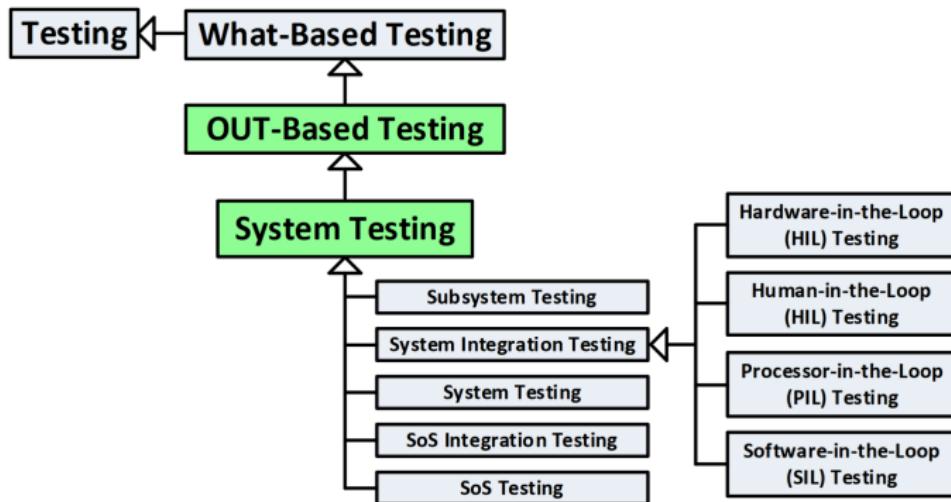
- The software testing literature is flawed, so don't assume everyone is on the same page



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

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