Effectiveness of Exploratory Testing

An empirical scrutiny of the challenges and factors affecting defect detection efficiency

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Agenda

- Paper 1:
  Exploratory Testing: A Systematic Literature Review
  - Introduction
  - Research questions
  - Research methods
  - Results

- Paper 2:
  An Experiment and Survey on the Effectiveness and Efficiency of Exploratory Testing and Traditional Test Case Based Testing
  - Introduction
  - Research questions
  - Research methods
  - Results

- Conclusions
Paper 1

Exploratory Testing: A Systematic Literature Review
Research Questions

- **RQ1** What is the state of the art in exploratory testing?
  - **RQ1.1** What definitions of exploratory testing are reported in literature?
  - **RQ1.2** What advantages and disadvantages are reported in literature?
  - **RQ1.3** What challenges are reported in literature?

- **RQ2** What is the state of the practice in exploratory testing?
  - **RQ2.1** How exploratory testing is practiced in testing industry?
  - **RQ2.2** What are the major factors affecting exploratory testing?
  - **RQ2.3** How good exploratory testing approach is for feature coverage?

- **RQ3** What are the challenges and factors in applying exploratory testing? (Findings from RQ1 and RQ2)
Research methods

- State-of-the-art
  - Systematic literature review (Research + Gray)
  - SLR results
  - Analysis/Discussion
- State-of-the-practice
  - Interview
  - Interview results
  - Conclusion
SLR Results

- Primary studies selection

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<th>Selected</th>
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<td>Gray Literature (Google)</td>
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SLR Results

- Research literature

Multi-step filtering of research studies using tollgate approach
SLR Results

• Gray literature

Multi-step filtering of gray studies using tollgate approach
SLR Results

• Literature trend

Trend of published and gray literature over the period 1979-2010
Exploratory Testing

Definition

- “Simultaneous learning, test design and test execution”. (James Bach)

- “Any testing to the extent that the tester actively controls the design of the tests as those tests are preformed and uses information gained while testing to design new and better tests”. (Tinkham and Kaner)

- Purposeful wandering, navigating through a space with a general mission, but without a pre-scripted route. Exploration involves continuous learning and experimenting”. (Kaner, Bach and Petticord)
Exploratory Testing

• No pre-designed test cases
• Controlled by Tester
• Results feedback
• Purposeful wandering

Simultaneous Learning
Exploratory Testing

- Adaptability
  - Learning of system
  - Perform complementary testing
  - Testing under time constraints
  - Targeted testing

- Suitability and non-suitability
Exploratory Testing

• Challenges
  – Explaining ET to customer and changing their traditional mind set from scripted testing
  – Coaching testers to perform ET professionally
  – Misconceptions related to ET
Exploratory Testing
Exploratory Testing

Factors

- Product
  - Technology
  - Web or client installed
  - Claims
  - Features
  - Customer type
  - User types

- Technology
  - Application
  - Platform
  - Architecture
  - Risk Levels
  - Host environment
  - Organizational setup

- Project
  - Stakeholders
  - Departments
  - Time line
  - Team competency
  - Resource
  - Tools
  - Risk Factors
Exploratory Testing
Customer Communication

- What and how is planned forward?
- What have you tested?
- How do we know that you have tested correctly?
- Traceability of test cases to requirements.
- How the test cases can be reused?
- What do you need to know about system?
- What documentation level?
- How much do we need to document?
- Is it reusable?
- Which format the results are required?
- When do you need this information?
Exploratory Testing

- Major factors affecting in applying ET
  - Explaining to customer
  - Coaching testers
  - Misconceptions
  - Lack of tester’s interest
  - Improper planning
  - Managers/customers are afraid of change
An Experiment and Survey on the Effectiveness and Efficiency of Exploratory Testing and Traditional Test Case Based Testing
Research Problem

- **Objects of study**  Exploratory and test case based testing.

- **Purpose**  Compare and evaluate the testing approaches in terms of found bugs (and bug type) in provided limited time.

- **Quality focus**  Defect detection efficiency and effectiveness of testing approaches.

- **Perspective**  Tester and research point of view

- **Context**  Industry practitioners and academia students. The study is conducted as a Multi-test within object study
Research Questions

• **RQ-1**: How does using a testing approach (ET or TCT) affect the number of detected defects in limited provided time?

  – *Null Hypothesis H1.0* There is no difference in the number of detected defects between ET and TCT.
  – *Hypothesis H1.1* More defects are detected with ET than TCT approach
  – *Hypothesis H1.2* More defects are detected with TCT than ET approach
Research Questions

• **RQ-2**: How does using ET or TCT affect the type of detects identified?
  
  - *Null Hypothesis H2.0* There is no difference in the type of detected defects between using ET or TCT approach

• **RQ-3**: How does using ET or TCT affect the number of false defect reports?
  
  - *Null Hypothesis H3.0* There is no difference in the number of false defect reports between using ET or TCT testing approach
Research Methods

• **Experiment**
  - Formal, rigorous and controlled investigation
  - Factors identified and manipulated
  - Provides
    - Execution control
    - Measurement control
    - Ease of replication

• **Survey**
  - To understand and quantify the perception of approaches
Experiment Design

• Subjects
  – Obtain consent
  – Sensitive results

Total 70: 24 from industry and 46 from academia

ET = 35
TCT = 35

Characteristics of academia subjects

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>$\bar{x}$</th>
<th>$\bar{\sigma}$</th>
<th>$\sigma$</th>
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<td>0.583</td>
<td>1</td>
<td>0.503</td>
</tr>
<tr>
<td>Testing experience (yrs)</td>
<td>0.291</td>
<td>0</td>
<td>0.464</td>
</tr>
</tbody>
</table>

Characteristics of industry subjects

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>$\bar{x}$</th>
<th>$\bar{\sigma}$</th>
<th>$\sigma$</th>
</tr>
</thead>
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<tr>
<td>SW dev experience (yrs)</td>
<td>2.954</td>
<td>2</td>
<td>2.514</td>
</tr>
<tr>
<td>Testing experience (yrs)</td>
<td>4.045</td>
<td>3</td>
<td>1.91</td>
</tr>
<tr>
<td>TCT based Testing experience (yrs)</td>
<td>3.5</td>
<td>3</td>
<td>2.738</td>
</tr>
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</table>
# Experiment Design

<table>
<thead>
<tr>
<th>Phase</th>
<th>ET – group</th>
<th>TCT – group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing Session</td>
<td>Exploratory Testing</td>
<td>Test Case based Testing</td>
</tr>
</tbody>
</table>

## Testing session detail

<table>
<thead>
<tr>
<th>Phase</th>
<th>Length</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session setup</td>
<td>15 mins</td>
<td>• Instructions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fill in pre-survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Access remote environment</td>
</tr>
<tr>
<td>Functional testing</td>
<td>90 mins</td>
<td>• Functional testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Report the bugs</td>
</tr>
<tr>
<td>Survey and reports handling</td>
<td>15 mins</td>
<td>• Fill post-survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Hand over defect reports/logs</td>
</tr>
</tbody>
</table>
Experiment Design

- Testing Approach (Factor)
  - Exploratory Testing (Treatment)
  - Test Case based Testing (Treatment)
- Defects count (Response variable)
Experiment Design

**elements**

- **Instrumentation**
  - Test object, guidelines, test case design template, defect report, ET charter and survey questionnaires

- **Blocking variables**
  - Actual defects in software, total number & type and difficulty of detecting them

- **Parameters**
  - (Software under test, subject properties, tools, test execution time and test environment)

- **Internal replication**
  - 70 internal replications
Results

• **Experimental data**
  – True defects
    • Detection difficulty
    • Technical type
    • Defect severity
  – False defects

• **Survey data**
  – Perceived coverage
  – Perceived quality
  – Perception of testing approaches
  – Challenges of testing approach
Experiment Results

• True defects count

![Bar chart showing true defects count per testing approach with ET and TCT categories.]

<table>
<thead>
<tr>
<th>Testing approach</th>
<th>Found defects per subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET</td>
<td>$\bar{x} = 8.342$</td>
</tr>
<tr>
<td></td>
<td>$\sigma = 4.214$</td>
</tr>
<tr>
<td></td>
<td>$SE_{\bar{x}} = 0.712$</td>
</tr>
<tr>
<td>TCT</td>
<td>$\bar{x} = 1.828$</td>
</tr>
<tr>
<td></td>
<td>$\sigma = 1.822$</td>
</tr>
<tr>
<td></td>
<td>$SE_{\bar{x}} = 0.308$</td>
</tr>
</tbody>
</table>

![Box plot showing detected true defects per subject with ET and TCT categories.]

two-tailed $t$-test
statistical significance value $p = 0.000$
Experiment Results

- False defects count

![Graph showing false defects count per testing approach]

<table>
<thead>
<tr>
<th>Testing approach</th>
<th>False defects per subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET</td>
<td>0.771, 1.628</td>
</tr>
<tr>
<td>TCT</td>
<td>1.257, 2.477</td>
</tr>
</tbody>
</table>

- Two-tailed Mann-Whitney statistical significance value $p = 0.584$
Experiment Results

- Detection difficulty

<table>
<thead>
<tr>
<th>Mode</th>
<th>ET</th>
<th>TCT</th>
<th>ET/TCT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = easiest</td>
<td>73</td>
<td>22</td>
<td>331 %</td>
<td>95</td>
</tr>
<tr>
<td>1</td>
<td>117</td>
<td>27</td>
<td>433 %</td>
<td>144</td>
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<tr>
<td>2</td>
<td>72</td>
<td>11</td>
<td>654 %</td>
<td>83</td>
</tr>
<tr>
<td>3 = hardest</td>
<td>30</td>
<td>2</td>
<td>1500 %</td>
<td>32</td>
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<tr>
<td>Total</td>
<td>292</td>
<td>62</td>
<td>470 %</td>
<td>354</td>
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</tbody>
</table>

Detection difficulty distribution

- ET: Easy, TCT: Total
Experiment Results

- Technical type

<table>
<thead>
<tr>
<th>Technical Type</th>
<th>ET</th>
<th>TCT</th>
<th>ET/TCT</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Documentation</td>
<td>5</td>
<td>5</td>
<td>100%</td>
<td>10</td>
</tr>
<tr>
<td>GUI</td>
<td>19</td>
<td>8</td>
<td>238%</td>
<td>27</td>
</tr>
<tr>
<td>Inconsistency</td>
<td>8</td>
<td>4</td>
<td>200%</td>
<td>12</td>
</tr>
<tr>
<td>Missing function</td>
<td>65</td>
<td>5</td>
<td>1300%</td>
<td>70</td>
</tr>
<tr>
<td>Performance</td>
<td>62</td>
<td>5</td>
<td>1240%</td>
<td>67</td>
</tr>
<tr>
<td>Technical defect</td>
<td>44</td>
<td>2</td>
<td>2200%</td>
<td>46</td>
</tr>
<tr>
<td>Usability</td>
<td>17</td>
<td>11</td>
<td>155%</td>
<td>28</td>
</tr>
<tr>
<td>Wrong function</td>
<td>72</td>
<td>22</td>
<td>327%</td>
<td>94</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>292</td>
<td>62</td>
<td>471%</td>
<td>354</td>
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</table>
Experiment Results

- Defect severity

<table>
<thead>
<tr>
<th>Severity</th>
<th>ET</th>
<th>TCT</th>
<th>ET/TCT</th>
<th>Total</th>
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<tr>
<td>Negligible</td>
<td>13</td>
<td>9</td>
<td>144%</td>
<td>22</td>
</tr>
<tr>
<td>Minor</td>
<td>49</td>
<td>12</td>
<td>408%</td>
<td>61</td>
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<tr>
<td>Normal</td>
<td>99</td>
<td>25</td>
<td>396%</td>
<td>124</td>
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<tr>
<td>Severe</td>
<td>108</td>
<td>14</td>
<td>771%</td>
<td>37</td>
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<tr>
<td>Critical</td>
<td>23</td>
<td>2</td>
<td>1150%</td>
<td>110</td>
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<tr>
<td>Total</td>
<td>292</td>
<td>62</td>
<td>471%</td>
<td>354</td>
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</tbody>
</table>
Survey Results

- Perceived coverage

Not covered at all, Covered superficially

Basic function well covered, covered thoroughly

\[ t\text{-test two tailed } p = 0.000 \]
Survey Results

Easiness to apply testing approach

<table>
<thead>
<tr>
<th>Difficulty</th>
<th>Neutral</th>
<th>Very easy</th>
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<tbody>
<tr>
<td>ET</td>
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<td>0</td>
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<td>TCT</td>
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<td>0</td>
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<tr>
<td>Total</td>
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</table>

Usefulness for structuring and guiding

<table>
<thead>
<tr>
<th>Hinder</th>
<th>Neutral</th>
<th>Very useful</th>
</tr>
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<tbody>
<tr>
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<td>1</td>
</tr>
<tr>
<td>TCT</td>
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<td>2</td>
</tr>
<tr>
<td>Total</td>
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Mann-Whitney test, $p = 0.221$

Mann-Whitney test, $p = 0.000$
Survey Results

Usefulness for detecting defects

<table>
<thead>
<tr>
<th></th>
<th>Hinder 1</th>
<th>2</th>
<th>3</th>
<th>Neutral 4</th>
<th>5</th>
<th>6</th>
<th>Very useful 7</th>
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<tbody>
<tr>
<td>ET</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>9</td>
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<td>9</td>
<td>9</td>
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<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>19</td>
<td>18</td>
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<td>4</td>
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Mann-Whitney test, $p = 0.307$
Contribution

- Systematic Literature Review
- State of the practice knowledge
- Empirical evaluation of defect detection efficiency and effectiveness in exploratory testing
Thank you!

Questions?