Analyzing Student Debugging Practices and Project Outcomes

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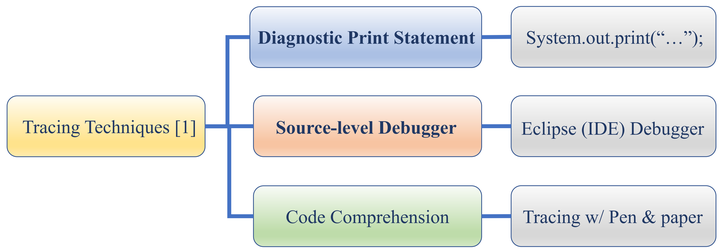
Identifying Debugging Behaviors in Intermediate Programmers

- Intermediate programmers often spend a lot of time debugging
- In a post-CS2 Data Structures and Algorithms course, we used IDE clickstream data to analyze detailed debugging behavior
- We hypothesize that there are differing debugging behaviors exhibited, and that differing behaviors lead to differing project outcomes

Research Questions

- To what *extent* is a particular debugging technique being used?
- Does it matter *when* in the project lifecycle that debugging takes place?
- Can a particular *type* of debugging technique lead to better project score?

Different Debugging Techniques



We focus on two debugging techniques:
1. Diagnostic Print Statements and
2. Source-level Debugger

Diagnostic Print Statement (DPS) Classifier

We want to identify those print statements that the students use for debugging purposes *i.e.* DPS; this is not a trivial process.

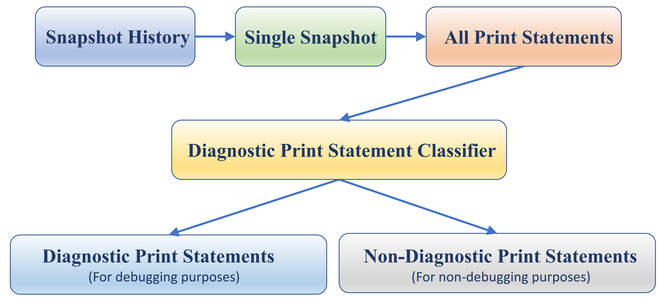
1. Exclude Commented Print Statements
2. Exclude Trivial (Delimiter) Print Statements
3. Exclude Project Specific (Required) Statements

DPS Examples

```
System.out.print(tempValue);
System.out.print("Success!");
```

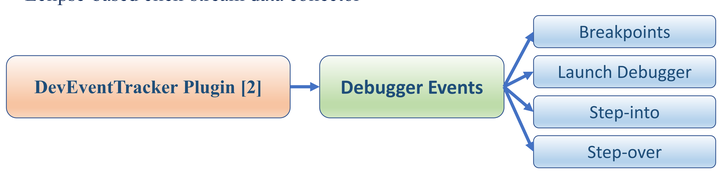
Extracting Debugging Behavior

1. Extracting DPS from Code Snapshots



2. Extracting Eclipse Debugger Events via DevEventTracker* [2]

* Eclipse-based click-stream data collector



Findings

Distribution of Different Debugging Techniques

- **87.21%** of students used the DPS
- **75%** of students used the Eclipse Debugger.
- Most students use both the DPS and the Eclipse Debugger.
- Debugging early and often showed a weak positive correlation with project performance.

$$corr\ coeff = \mathbf{0.19} \quad p - value < \mathbf{0.001}$$

Preliminary Evaluation using DPS Classifier

- **12** sample projects (3 samples from 4 different Projects)
- Print Statements: Total 1467* $(\mu = 122,\ \sigma = 89)$
- DPS: Total 611* $(\mu = 51,\ \sigma = 54)$

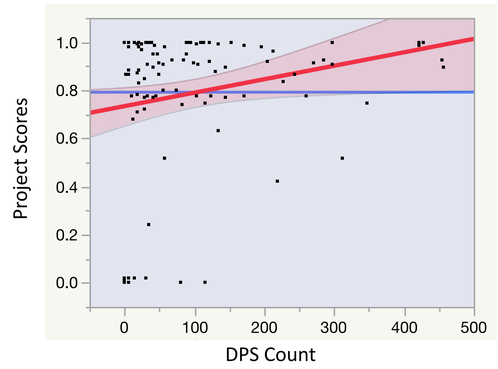
(* for all the intermediate snapshots)

Accuracy: 100%

Therefore, this classifier works well on this dataset.

Relationship with Project Score

1. Project Score vs DPS



$$p - value = 0.0347$$

$p - value < \alpha$ (0.05)
Hence, there is significant evidence that project scores correlate to DPS count.

$$R^2 = 0.0456$$

Therefore, 4.56% variability in the project score can be explained by DPS count.

Figure: Project Score vs DPS Count (for Project 1)

2. Project Score vs Debugger Events

- More Debugger Events (step over, step into*)* → lower Project Score
  (The same student performed better in another project)
- Step over: p-value = **0.039** and Step into: p-value = **0.005**

Therefore, students tend to get lower Project Scores when they spend too much time on the **same bug**.

Key Results

- Students tend to perform better on the project when debugging takes place earlier in the overall project life-cycle.
- There is weak yet statistically significant evidence that both DPS and Debugger Events correlate to overall Project Score.
- Only 4.56% variability in Project Score can be explained by overall DPS count

Future Work

- We plan to focus on individual debugging sessions to find if one type of debugging technique is more effective than another.
- We plan to find out how the students verify that the bug is fixed, such as manual checking, writing new test-cases, and/or by submitting the project for evaluation.

References

[1] Murphy, Laurie, et al. "Debugging: the good, the bad, and the quirky--a qualitative analysis of novices' strategies." ACM SIGCSE Bulletin. Vol. 40. No. 1. ACM, 2008.

[2] Kazerouni, Ayaan M., et al. "DevEventTracker: Tracking development events to assess incremental development and procrastination." Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education. ACM, 2017.

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