Typing Exercises as Interactive Worked Examples for Deliberate Practice in CS Courses

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Computer Science enrollment is currently at an all-time high in the US (Bureau of Labor Statistics, 2017)

However, early CS courses commonly experience a 30-50% drop/fail attrition rate

Novice CS students struggle with syntax errors, rather than problem-solving (Altadmri, Brown, 2015)
Computer Scientists store recurring basic plan mental models to apply a learned concept to a similar problem (Soloway, Ehrlich, 1984)

Debugging can take the majority of novices’ time but can be mitigated with canned code (Brooks, 1977)

Multiple worked examples improve students’ abstract mental models (Zhi et al, 2018)
Novel CS Exercises

The emergence of novel CS exercises has created exercises like Parson’s Puzzles, Output Prediction, and Bug Localization. Early computer magazines provided worked examples needed to be retyped for making computer games (Usbourne, 1982; Antic, 1982-90).
CS novices can benefit from retyping example code to build their own recurring basic plans without the risk of simply copying and pasting the code.

Typing exercises give students canned code, which can be used as a template for future exercises.
TYPOS is a low-level CS Exercise Platform

Students could **complete exercises** as often as they wanted and **download copies** after completion.

Information and Images Available at [go.ncsu.edu/typos](http://go.ncsu.edu/typos)
Research Questions

RQ1 - Do students refer to typing exercises while working on other tasks?

RQ2 - How do different patterns of use correlate with student performance?

RQ3 - Is there a correlation between completion of typing exercises and build failures on assignments?
TYPOS was deployed into three offerings of a second semester CS course which taught Java

Homework and Projects were graded through unit and code coverage tests on the Jenkins Continuous Integration system
  Comments were graded by TAs

3 - 4 optional typing exercises were released each lecture mirroring the day’s topic
  Total Number of Exercises Released per Offering: 66

In total, 337 students made 7,334 views, 10,097 attempts, and 3,024 completions
Usage Analysis

Student Activity for Fall 2018

Daily Activity for the Semester
Usage Analysis

Student Activity for Fall 2018

Students almost exclusively worked on TYPOS before class lecture
The majority of students used TYPOS at the beginning but activity shifted to prior to exams.
# Usage Analysis

Active Users (77) comprised 75% of all activity on TYPOS

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
<th>Avg Views</th>
<th>Avg Attempts</th>
<th>Avg Completes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>25</td>
<td>11</td>
<td>8</td>
<td>2</td>
<td>-</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Barely</td>
<td>235</td>
<td>109</td>
<td>85</td>
<td>21</td>
<td>3</td>
<td>17</td>
<td>7.5</td>
<td>12.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Viewers</td>
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<td>9</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>58.1</td>
<td>13.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Attempters</td>
<td>26</td>
<td>11</td>
<td>11</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>60.2</td>
<td>56.2</td>
<td>18.0</td>
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<tr>
<td>Completers</td>
<td>34</td>
<td>19</td>
<td>14</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>88.4</td>
<td>160.8</td>
<td>52.1</td>
</tr>
</tbody>
</table>

Active Users were classified as **viewers**, **attempters**, or **completers**
Student Performance Analysis

Regular completers earned higher exam grades and final course grades when compared to other regular users.

Student exam and course grades by category.
Initially low performing completers benefited from the additional low-level practice.

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
<th>Course Grades</th>
<th>Exam Learning Gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Completers</td>
<td>34</td>
<td>0.065</td>
<td>0.161</td>
</tr>
<tr>
<td>Initially Low-Performing Students</td>
<td>16</td>
<td>0.038*</td>
<td>0.041*</td>
</tr>
</tbody>
</table>

P-values for all and lower-performing completers across course grade and learning gains (* p<0.05)
This course used the **Jenkins** Continuous Integration system to assess student submissions with three feedbacks:

- **Red Ball**: Build could not compile
- **Yellow Ball**: Build compiled, but failed tests
- **Green Ball**: Build successfully completed all tests
We assessed all active users TYPOS behavior with Jenkins’ red ball status

All TYPOS usage was **negatively correlated** with build failures

<table>
<thead>
<tr>
<th>Category</th>
<th># Viewed</th>
<th># Attempted</th>
<th># Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Students</td>
<td>-0.045**</td>
<td>-0.048**</td>
<td>-0.110**</td>
</tr>
<tr>
<td>Initially Low-Performing</td>
<td>-0.132*</td>
<td>-0.050**</td>
<td>-0.144**</td>
</tr>
<tr>
<td>Performing Students</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pearson’s r Comparing TYPOS Activity to Build Failures (* p<0.05, ** p<0.01)
Conclusions

RQ1 - How do different patterns of use correlate with student performance?
Regular completers earned higher course grades, especially in initially low-performing students

RQ2 - Do students refer to typing exercises while working on other tasks?
Students reviewed TYPOS prior to exams and completed exercises prior to lecture

RQ3 - Is there a correlation between completion of typing exercises and build failures in other work?
Reviewing and retyping worked examples reduced the number of build failures on Jenkins
In a perfect world, everyone would master topics immediately.
However, in reality, there are multiple ways to practice
By mapping prior student activity sequences, we seek to provide students with their next best step to ensure they are mastering topics efficiently.