Partnership Characteristics and Student Performance in an Introductory Computer Science Course

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ELECTRICAL ENGINEERING AND COMPUTER SCIENCE
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Outline

• Introduction and related work
• Data set and methods
• Results
• Limitations and conclusions
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Pair Programming

• A software development technique
• Two programmers + one workstation
• How it is supposed to work:
  • “Driver” controls mouse and keyboard
  • “Navigator” observes and offers solutions to problems
  • Programmers switch roles frequently
• What is NOT supposed to happen:
  • Divide-and-conquer
  • Driver does all of the work
Pair Programming – Prior Work

- Higher project scores in an introductory computer science course
  - McDowell et al.
- Better performance on individual work and exams
  - Mendes et al.
Pair Programming

- Last year at ASEE:
- Better project performance, especially in lowest GPA quartile
  - CS2 optional partnerships
  - CS3 all individual work
  - Giugliano et al.
- Compared students who chose to partner with those who chose to work alone
- In this paper, we look to combine performance data of previous work with partnership compatibility
Partnership Compatibility

• Students desire compatible partnerships
  • Nagappan et al.

• Mixed-gender partnerships less likely to report compatibility than same-gender
  • Katira et al.

• Differences in personalities did not contribute to academic performance of partnership
  • Personalities measured using the five factor model
  • Salleh et al. (2009) and Hannay et al. (2010)
Research Questions

• What kinds of partnerships form? Are these partnerships balanced?
• Do balanced partnerships perform better or worse than unbalanced ones?
• Does starting projects early affect performance?
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Data Set

1,434 records of students enrolled in CS2

Filtering

1,343 records after filtering students who withdrew, audited, etc.

Removing students who worked alone

510 distinct partnerships, or 869 unique individuals who partnered

• Large research university
• Data set included:
  • Two semesters of CS2 data
  • Project scores
  • Exam scores
  • Partner status for each project in CS2
  • Date and time of project submissions
  • Gender
  • Cumulative GPA
  • Partnerships only
Partnership Metrics

• Parity:
  • Difference in partners’ GPAs normalized to a [0,1] scale
  • Calculated as: \( P = \frac{4.0 - |(GPA_0 - GPA_1)|}{4.0} \)
  • \( P=0 \) implies opposite GPAs
  • \( P=1 \) implies identical GPAs

• Gender makeup:
  • Two men, two women, mixed gender

• Work habits or early-start:
  • How early a partnership started a project
  • Calculated as: \( \frac{1}{n} \sum_{i=1}^{n} z_i \) where:
    • \( n \): number of projects that partners worked together on
    • \( z_i \): number of days early partnership first submitted the i-th project they worked together on, represented as a z-score

• Independent variables
Performance Metrics

- Project performance:
  - Average grade of all projects completed by partnership

- Exam performance:
  - Average of two partners’ exam grades

- Course performance:
  - Average of two partners’ course letter grade
  - Converted letter grade to number on 4.0 scale

- Dependent variables
Partnership GPA vs. Parity
Descriptive Statistics

<table>
<thead>
<tr>
<th>Gender Composition</th>
<th>Count</th>
<th>Average GPA</th>
<th>Average Partnership GPA Parity</th>
<th>Average “Early-start on Projects” Z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Women</td>
<td>62</td>
<td>3.398</td>
<td>0.886</td>
<td>-0.031</td>
</tr>
<tr>
<td>Two Men</td>
<td>319</td>
<td>3.419</td>
<td>0.890</td>
<td>-0.010</td>
</tr>
<tr>
<td>Mixed Gender</td>
<td>129</td>
<td>3.416</td>
<td>0.904</td>
<td>0.033</td>
</tr>
<tr>
<td>All Individuals</td>
<td>510*</td>
<td>3.415</td>
<td>0.893</td>
<td>-0.002</td>
</tr>
</tbody>
</table>

*Note: One partnership was removed, as it was an outlier. This did not affect the trends we saw in our results.
Statistical Methods

• Z-scores for grade data
  • Data was collected over different semesters
• Z-scores for work habits metric
  • Each project had a different time frame
• Calculated per-semester, per-assignment
• Used multivariate ANOVA to evaluate statistical significance of observations
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Results – Parity

• No significant association with project grade after considering average GPA
• No significant association with exam grade after considering average GPA

<table>
<thead>
<tr>
<th></th>
<th>Average Exam Score</th>
<th></th>
<th>Average Project Score</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
<td>df</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>Parity</td>
<td>0.01</td>
<td>1</td>
<td>0.03</td>
<td>0.871</td>
</tr>
<tr>
<td>Average GPA</td>
<td>61.51</td>
<td>1</td>
<td>242.99</td>
<td>0.000</td>
</tr>
<tr>
<td>Parity:GPA</td>
<td>0.16</td>
<td>1</td>
<td>0.65</td>
<td>0.422</td>
</tr>
</tbody>
</table>
Results – Work Habits

- Correlation with exam scores and project scores were statistically significant
- Significant, even after considering average GPA

<table>
<thead>
<tr>
<th></th>
<th>Average Exam Score</th>
<th></th>
<th>Average Project Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
<td>df</td>
<td>F</td>
</tr>
<tr>
<td>Work Habits</td>
<td>2.20</td>
<td>1</td>
<td>8.70</td>
</tr>
<tr>
<td>Average GPA</td>
<td>61.51</td>
<td>1</td>
<td>242.99</td>
</tr>
<tr>
<td>Work Habits:GPA</td>
<td>0.04</td>
<td>1</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Results – Work Habits

• Mean course grades higher for students who started projects earlier
  • Most significant change for students in lowest GPA quartiles

<table>
<thead>
<tr>
<th>GPA Q1</th>
<th>Work Habits Q1</th>
<th>Work Habits Q2</th>
<th>Work Habits Q3</th>
<th>Work Habits Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>C+ (2.3)</td>
<td>C+ (2.4)</td>
<td>C+/B- (2.6)</td>
<td>B- (2.7)</td>
<td></td>
</tr>
<tr>
<td>GPA Q2</td>
<td>B- (2.8)</td>
<td>B (3.0)</td>
<td>B (3.0)</td>
<td>B+ (3.2)</td>
</tr>
<tr>
<td>GPA Q3</td>
<td>B+ (3.2)</td>
<td>B+ (3.3)</td>
<td>B+ (3.3)</td>
<td>B+/A- (3.5)</td>
</tr>
<tr>
<td>GPA Q4</td>
<td>B+/A- (3.6)</td>
<td>A- (3.7)</td>
<td>A- (3.7)</td>
<td>A- (3.7)</td>
</tr>
</tbody>
</table>
Results – Work Habits

• Results might imply that partnerships who start projects earlier learn material better

• However, variance explained by starting early is small compared to average GPA
Results – Gender Makeup

• No association between project scores and gender makeup
• Association between exam scores and gender makeup was significant
  • Specifically, two men tended to perform slightly better
  • In the future, would like to look into this further
• Mixed gender partnerships tended to have shorter durations
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Limitations

• Students chose whether to partner
• Students chose with whom to partner
• Class standing could affect parity metric
• No information or control on group dynamics
• Data set from multiple semester offerings of course
Conclusions

• Partnership parity was not associated with project or exam performance
• Starting projects early had a positive association with project and exam performance
• Students with below-median GPAs were associated with the greatest improvements from starting early
  • Lowest early-start quartile averaged a C+ in the course
  • Highest early-start quartile averaged a B- in the course
• Duration of partnerships was associated with gender composition
  • Same gender partnerships tended to last the entire semester
  • Mixed gender partnerships tended to span only one project or the entire semester