STRUCTURED PAIRING IN AN ELECTRONICS LABORATORY AND A MODEL OF RESEARCH MENTORING

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STUCTURET PAIRING IN AN ELECTRONICS LABORATORY

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Acknowledgements

This work was supported by the Grants for the Advancement of Teaching in Engineering Program and by the Illinois Foundry for Innovation in Engineering Education (iFoundry) at the University of Illinois at Urbana-Champaign.
ECE 110 is a design laboratory for first-year students at Illinois

Required for majors in electrical engineering, computer engineering, general engineering, industrial engineering

Introduces selected topics in electric circuits, electronics, digital logic, communications

Directed toward the design of an autonomous line-following vehicle in the laboratory

Each week: 3 hrs lecture, 3 hr lab
Laboratory instructors face common problems with student teams

Participation problems
  • Free riders
  • Dominant leaders
  • Divide-and-conquer

Student outcomes
  • Lack of confidence
  • Little increase in practical skills or conceptual understanding
How can student teams be structured to promote learning in labs?

Pair programming method in computer science (Williams & Kessler, 2000)
Students work in pairs to complete program
Simple roles: Driver and Navigator
Driver types specification or code
Navigator observes, comments, asks metacognitive questions
Students switch roles every 20 minutes
In a first course in computer science, pair programming improved …

Confidence
Satisfaction
Persistence

• After one year (all students): 71% vs. 42%
• After one year (female students): 60% vs. 22%

(McDowell, Werner, Bullock, & Fernald, 2006)
We designed structured pairing as a modification of pair programming

Driver wires circuits, adjusts multimeter
Navigator checks work, records data
Switch at designated points in lab procedure
Research Questions

How does structured pairing affect students’
  • Persistence in engineering
  • Confidence in laboratory skills
  • Satisfaction and attitudes

How do laboratory experiences of students in structured pairing compare with students in traditional lab sections?
We implemented and evaluated structured pairing in ECE 110 labs

Quasi-experiment, Fall 2009

- IRB Approval: University of Illinois IRB #10055
- 6 structured pairing, 7 traditional lab sections

Sequential mixed-methods design

(QUAN → qual)

- 40-item end-of-semester survey
- Final exam grades
- Two focus groups in January 2010
- College of Engineering enrollment data
Students in structured pairing and traditional sections were similar

<table>
<thead>
<tr>
<th></th>
<th>Structured</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students who consented</td>
<td>126</td>
<td>114</td>
</tr>
<tr>
<td>Students who completed survey</td>
<td>104</td>
<td>109</td>
</tr>
<tr>
<td>Average ACT-Math score</td>
<td>30.8</td>
<td>29.9</td>
</tr>
<tr>
<td>Average final exam score</td>
<td>68.7</td>
<td>68.1</td>
</tr>
<tr>
<td>Passed ECE 110 with C or better grade</td>
<td>102 (81%)</td>
<td>89 (86%)</td>
</tr>
</tbody>
</table>
**Were structured pairing students more likely to persist in engineering?**

No significant difference based on enrollment data

<table>
<thead>
<tr>
<th>% of students …</th>
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<th>Traditional</th>
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<tbody>
<tr>
<td>who took another engineering course the semester following ECE 110</td>
<td>93.7</td>
<td>93.0</td>
</tr>
<tr>
<td>majoring in engineering after 6 months</td>
<td>88.9</td>
<td>86.8</td>
</tr>
</tbody>
</table>
To measure confidence, satisfaction, attitudes, we administered a survey based on:

- Existing surveys
- Issues identified in ECE 110 lab

Reviewed by expert in survey design, 40 items:
- Comfort with lab tasks
- Confidence and satisfaction, discipline and course
- Teamwork
- Desire to persist
We compared structured pairing and traditional sections on 26 of 40 items.

Exploratory factor analysis: five factors

- Confidence in lab abilities (10 items)
- Satisfaction with and desire to persist in ECE (6 items)
- Team satisfaction (3 items)
- Desire to team in future (4 items)
- Lab satisfaction (2 items)

66% of total variance explained, $\alpha = .82$

One item removed
We found significant differences on three factors:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Structured (n = 59)</th>
<th>Traditional (n = 106)</th>
<th>Effect size $d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence in lab abilities</td>
<td>4.22*</td>
<td>3.93</td>
<td>.39</td>
</tr>
<tr>
<td>Satisfaction with and desire to persist in ECE</td>
<td>4.17</td>
<td>3.93</td>
<td>.32</td>
</tr>
<tr>
<td>Team satisfaction</td>
<td>4.57*</td>
<td>4.20</td>
<td>.51</td>
</tr>
<tr>
<td>Desire to team in future</td>
<td>4.59</td>
<td>4.39</td>
<td>.31</td>
</tr>
<tr>
<td>Lab satisfaction</td>
<td>4.21*</td>
<td>3.60</td>
<td>.67</td>
</tr>
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</table>

* $p < .05$, with Bonferroni-Holm correction
Structured pairing students perceived lower workload and difficulty

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<tr>
<th>Survey Item</th>
<th>Structured</th>
<th>Traditional</th>
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<tbody>
<tr>
<td>Workload of the ECE 110 laboratory</td>
<td>3.19*</td>
<td>3.49</td>
</tr>
<tr>
<td>Difficulty of the weekly laboratory tasks</td>
<td>3.35*</td>
<td>3.59</td>
</tr>
<tr>
<td>Difficulty of the final project</td>
<td>3.32*</td>
<td>3.56</td>
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* $p < .05$
Conclusions:
No negative impact on student learning or persistence in engineering
Increased confidence in lab abilities and satisfaction with team and lab experiences
Lower perceived difficulty and workload
Questions?
A DEVELOPMENTAL MODEL OF RESEARCH MENTORING

Renata A. Revelo and Michael C. Loui
Acknowledgement

This work was supported by the National Science Foundation under Grant CNS-0851957. The views, opinions, and conclusions expressed here are not necessarily those of the University of Illinois or the National Science Foundation.
We studied mentoring in a summer undergraduate research program.

Information Trust Institute (ITI) Summer Undergraduate Research Internship Program supported by NSF, ten weeks. Mentoring program for grad students followed Handelsman et al. (2005).
Graduate student mentors of undergrads learned mentoring skills

Half-day initial orientation
- Prior experiences, concerns
- Planning first week, setting expectations
- Start mentoring philosophy statements

Biweekly meetings throughout summer
- Discussed problems and solutions
- Different themes: giving and receiving feedback, diversity, writing and presenting
- Short scenarios from Handelsman et al.
Each graduate student wrote a mentoring philosophy statement

Similar to teaching philosophy statement
Draft at beginning of summer, revised at end
500-1000 word statement

“Why do we conduct research?”

“What are your goals for your students?”

“What personal characteristics or prior experiences influence the way you mentor?”
Each graduate student kept a weekly reflective journal

Four to six questions per week
What skills do you want to teach your undergraduate researcher? (Week 1)
How does your undergraduate researcher feel about the project now? (Week 5)
How has your definition of good mentoring changed over the summer? (Week 8)
We analyzed documents using grounded theory

Collected documents from 18 graduate student mentors in 2010, 2011, 2012

• Mentoring philosophy statements (draft, revised)
• Weekly reflective journal entries

Used grounded theory to create a four-stage developmental model of research mentoring
Stage 1
Student: Novice
Mentor: Director
Stage 2
Student: Apprentice
Mentor: Master
Stage 3
Student: Collaborator
Mentor: Guide
Stage 4
Student: Colleague
Mentor: Consultant
Over time, the primary responsibility shifts from mentor to student.

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The model explains conflicts between mismatched stages

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A Stage 4 mentor writes about a Stage 1 student (2012)

Week 2
Week 3
Week 5
Week 6
Week 8
The model advances over previous models of research mentoring

Gatfield (2005): four supervisory styles
Murphy, Bain, and Conrad (2007): four advising orientations
Lechuga (2011): three faculty roles

None of these defines student roles
None of these is developmental
We created a developmental model of research mentoring

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