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

MICHAEL C. LOUI

School of Engineering Education, Purdue University

Indiana University Purdue University Indianapolis
February 10, 2020

PURDUE UNIVERSITY

STURCTURED PAIRING IN AN ELECTRONICS LABORATORY

Nicholas D. Fila and Michael C. Loui

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.

PURDUE UNIVERSITY

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

https://uofi.box.com/s/ivlsbb5tq9u2kfs98ddjdssv39bvy6m9

http://www.youtube.com/watch?v=pa-DLQj-xhM

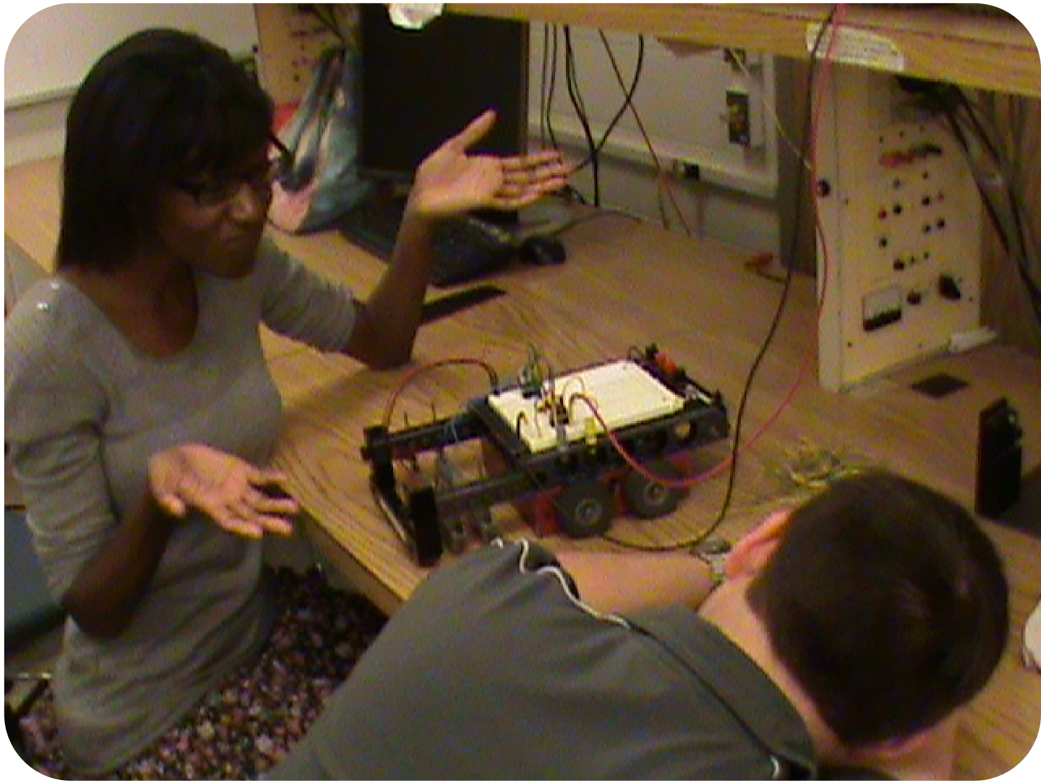
Laboratory instructors face common problems with student teams

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

Purdue University

In a first course in computer science, pair programming improved …

Confidence

Satisfaction

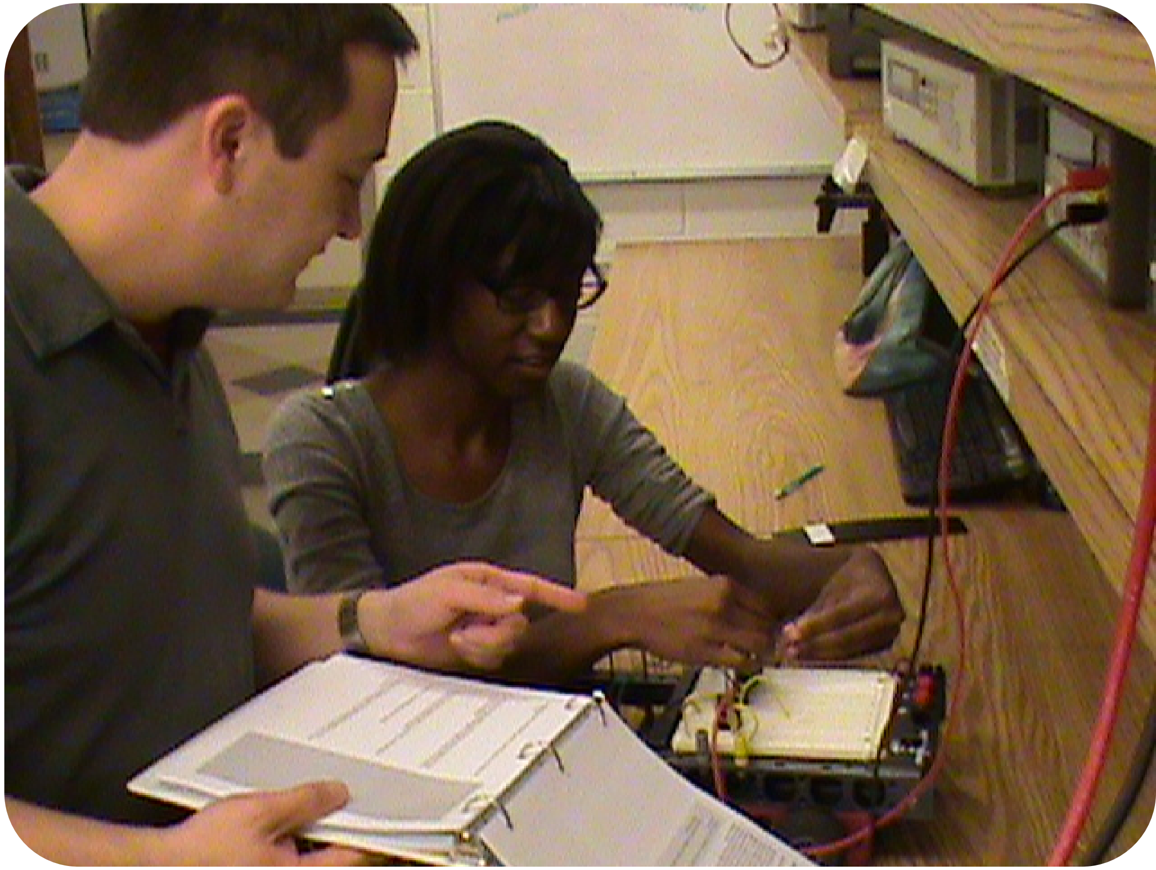
Persistence

- 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



PURDUE UNIVERSITY

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?

PURDUE UNIVERSITY

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

PURDUE UNIVERSITY

Students in structured pairing and traditional sections were similar

	Structured	Traditional
Students who consented	126	114
Students who completed survey	104	109
Average ACT-Math score	30.8	29.9
Average final exam score	68.7	68.1
Passed ECE 110 with C or better grade	102 (81%)	89 (86%)

PURDUE UNIVERSITY

Were structured pairing students more likely to persist in engineering?

No significant difference based on enrollment data

% of students …	Structured	Traditional
who took another engineering course the semester following ECE 110	93.7	93.0
majoring in engineering after 6 months	88.9	86.8

PURDUE UNIVERSITY

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

PURDUE UNIVERSITY

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

PURDUE UNIVERSITY

We found significant differences on three factors

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

* $p < .05$, with Bonferroni-Holm correction

PURDUE UNIVERSITY

Structured pairing students perceived lower workload and difficulty

Survey Item	Structured	Traditional
Workload of the ECE 110 laboratory	**3.19***	3.49
Difficulty of the weekly laboratory tasks	**3.35***	3.59
Difficulty of the final project	**3.32***	3.56

* $p < .05$

PURDUE UNIVERSITY

Structured pairing improves students' confidence and satisfaction in lab

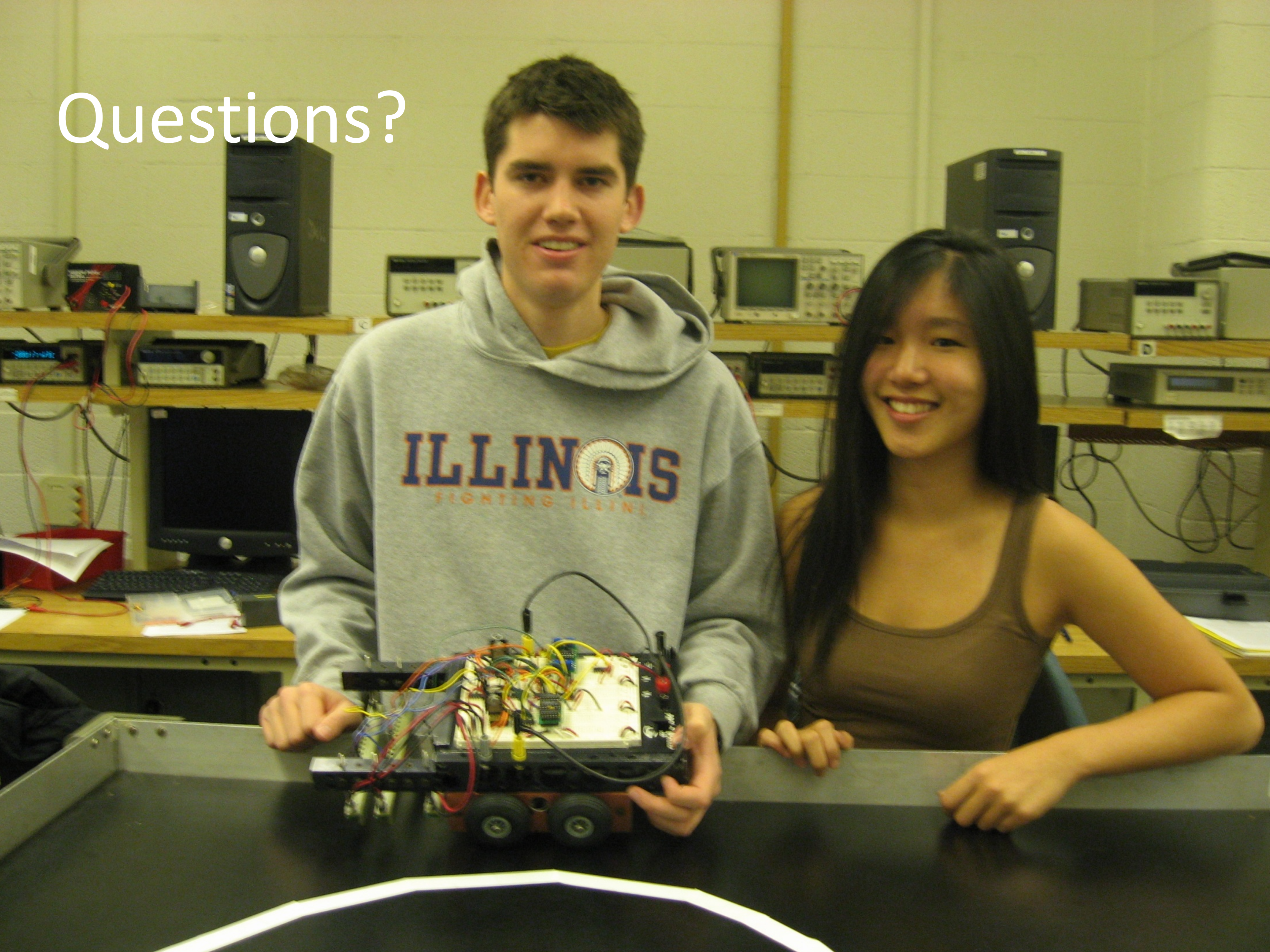
Conclusions:

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

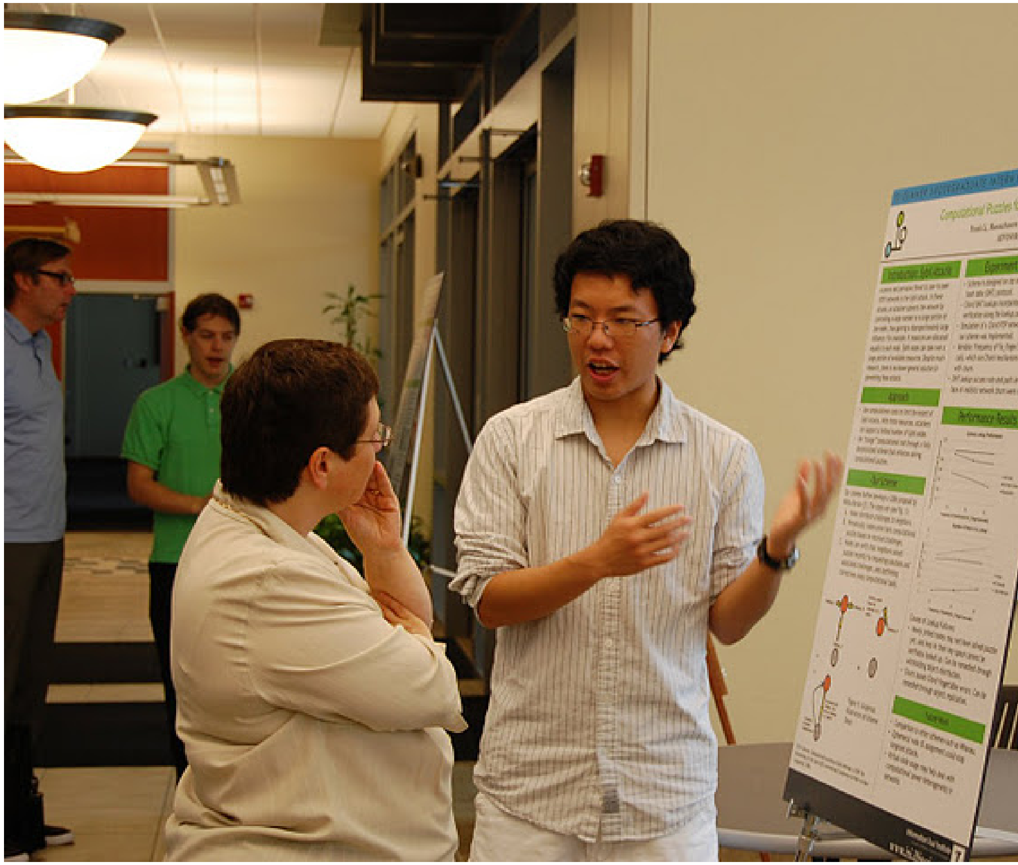
Acknowledgement

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.

PURDUE UNIVERSITY

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)



PURDUE UNIVERSITY

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.

PURDUE UNIVERSITY

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?”

PURDUE
UNIVERSITY

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)

PURDUE UNIVERSITY

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

Stage	Student role	Mentor role	Primary responsibility
1	Novice	Director	Mentor
2	Apprentice	Master	Mentor
3	Collaborator	Guide	Equal
4	Colleague	Consultant	Student

The model explains conflicts between mismatched stages

Stage	Student role	Mentor role	Primary responsibility
1	Novice	**Director**	Mentor
2	Apprentice	Master	Mentor
3	Collaborator	Guide	Equal
4	**Colleague**	Consultant	Student

PURDUE UNIVERSITY

The model explains conflicts between mismatched stages

Stage	Student role	Mentor role	Primary responsibility
1	**Novice**	Director	Mentor
2	Apprentice	Master	Mentor
3	Collaborator	Guide	Equal
4	Colleague	**Consultant**	Student

PURDUE UNIVERSITY

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

Stage	Student role	Mentor role	Primary responsibility
1	Novice	Director	Mentor
2	Apprentice	Master	Mentor
3	Collaborator	Guide	Equal
4	Colleague	Consultant	Student

References

Fila, N. D., & Loui, M. C. (2014). Structured pairing in a first-year electrical and computer engineering laboratory: The effects on student retention, attitudes, and teamwork. *International Journal of Engineering Education*, *30*(*4*), 848-861.

Revelo, R. A., & Loui, M. C. (2016). A developmental model of research mentoring. *College Teaching*, *64*(3), 119-129. doi: 10.1080/87567555.2015.1125839.

PURDUE UNIVERSITY