

# Long Term Effects of Partner Programming in an Introductory Computer Science Sequence

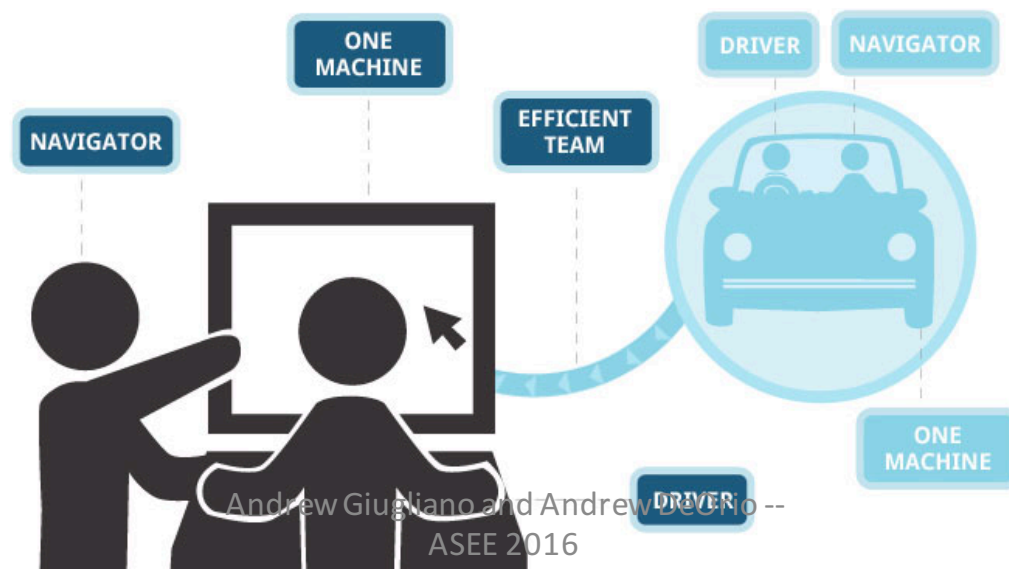
Andrew Giugliano and  
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ELECTRICAL ENGINEERING  
AND COMPUTER SCIENCE  
UNIVERSITY OF MICHIGAN

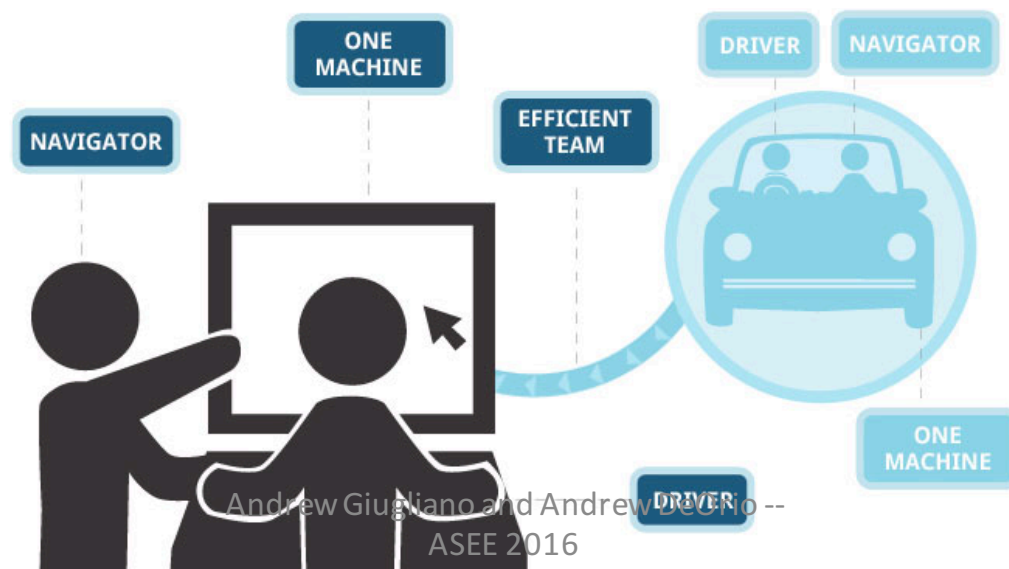
# Pair Programming

- A software development technique
- Two programmers + one workstation
- Higher student performance in introductory computer science courses



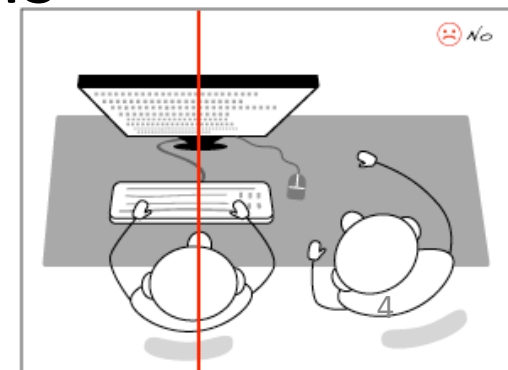
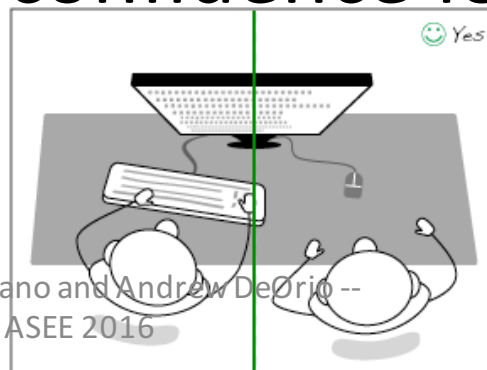
# Pair Programming

- Higher project scores and similar exam scores
  - McDowell et al.
- Higher student retention rates in first year computing courses
  - Nagappan et al. and McDowell et al.



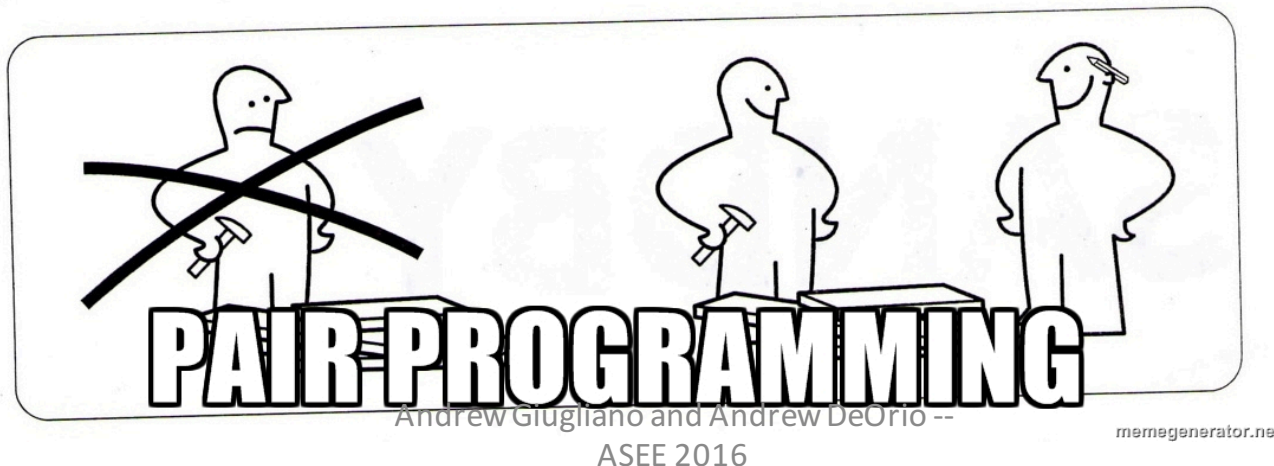
# Pair Programming + Demographics

- Other research has examined its impact on different demographic groups
- Higher programming skills for students with lower SAT scores
  - Braught et al.
- Higher performance especially for students who begin with low confidence levels
  - Wood et al.

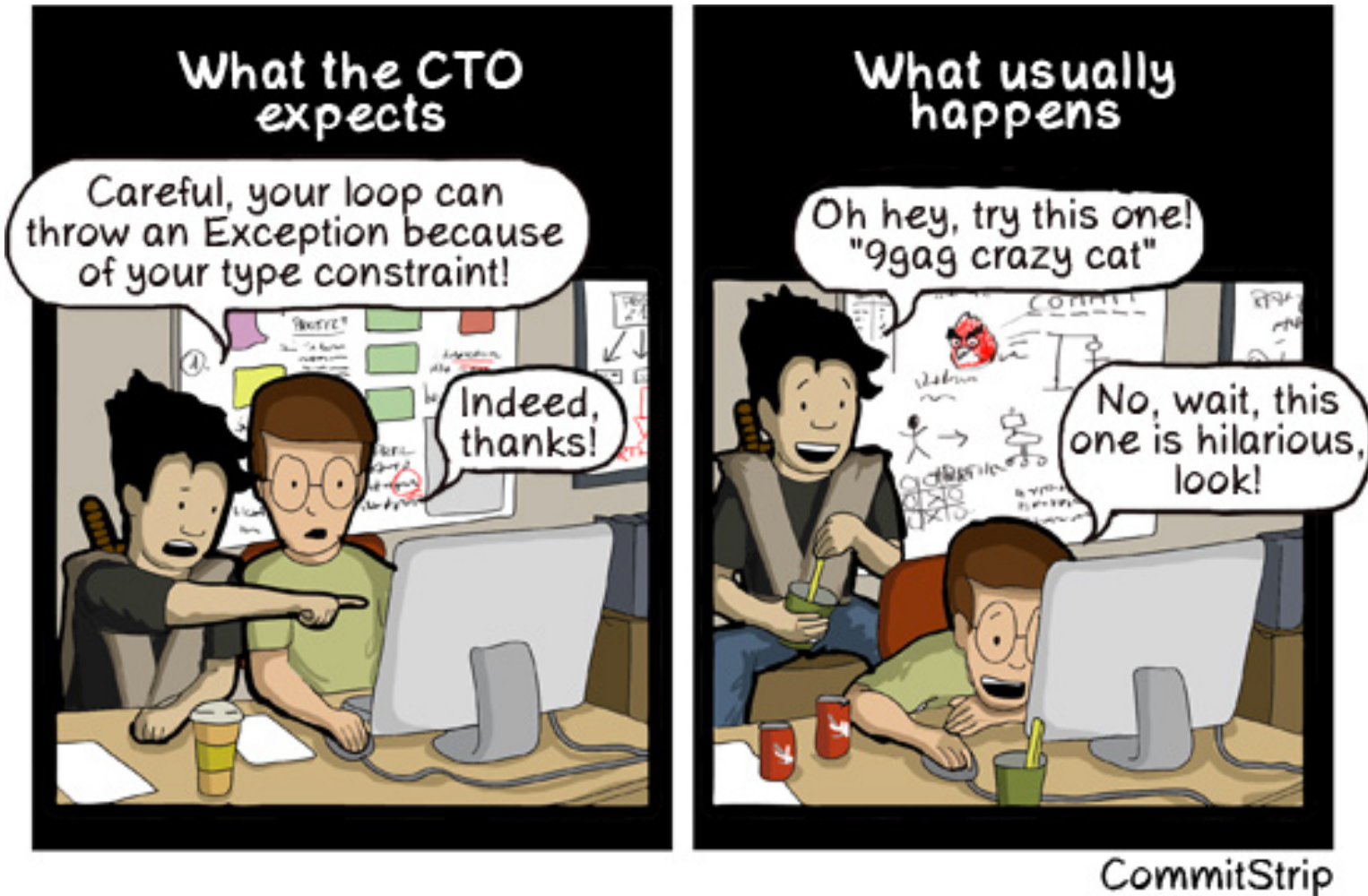


# Pair Programming in Industry

- Researchers have also extensively examined pair programming and its effects in industry
- Higher-quality programs with quicker time-to-market
  - Williams et al. (2000) and Cockburn et al. (2001)



# Pair Programming Concerns



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Comic: <https://developer.atlassian.com/blog/2015/05/try-pair-programming/>

# Pair Programming Concerns

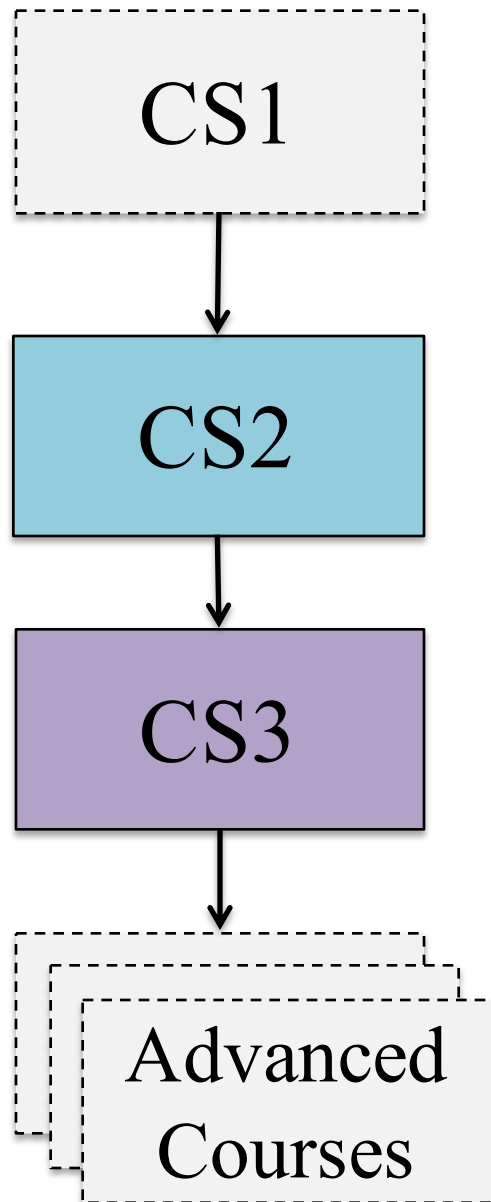
- Students may divide the work instead of working together, missing some material
- Students may become dependent on partnerships, leading to future difficulty working independently
- Key question: what happens in future courses?

# Research Questions

- Are student partnerships during a past semester associated with changes in student performance during a future semester while working alone?
- Do observations about student partnerships vary with different demographic groups?



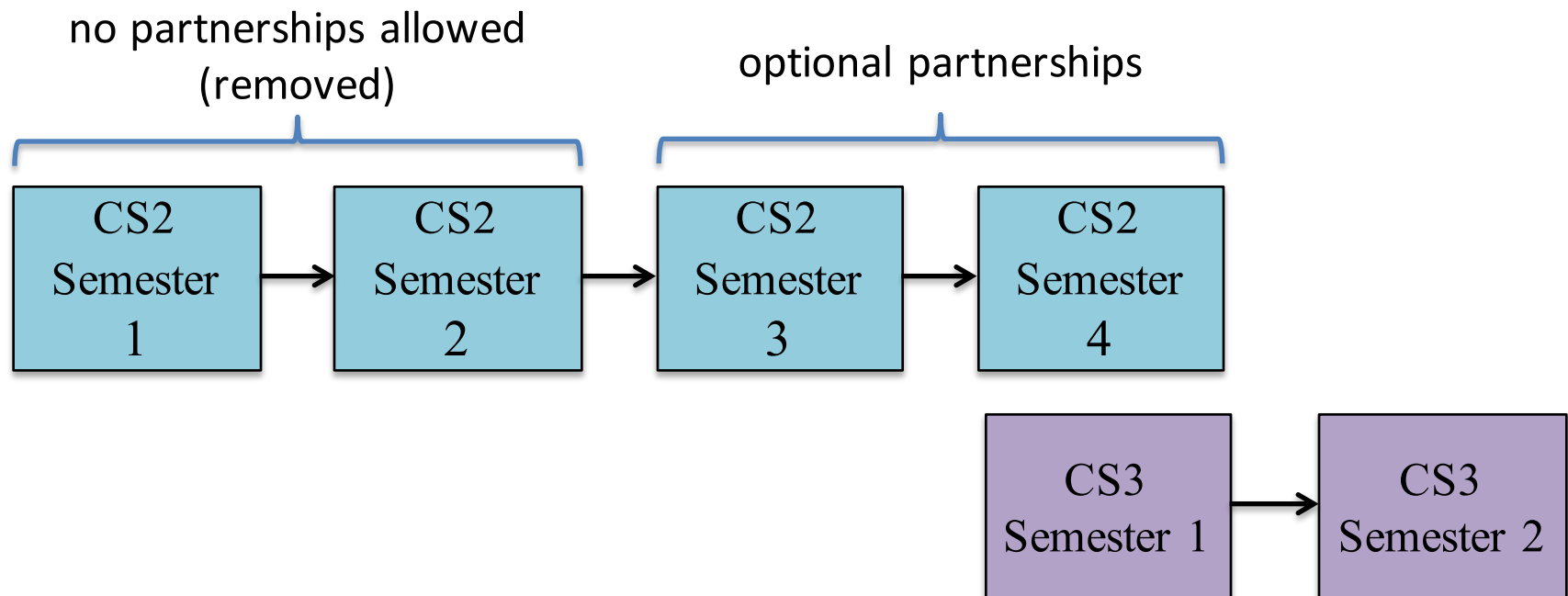
# Our Data Set



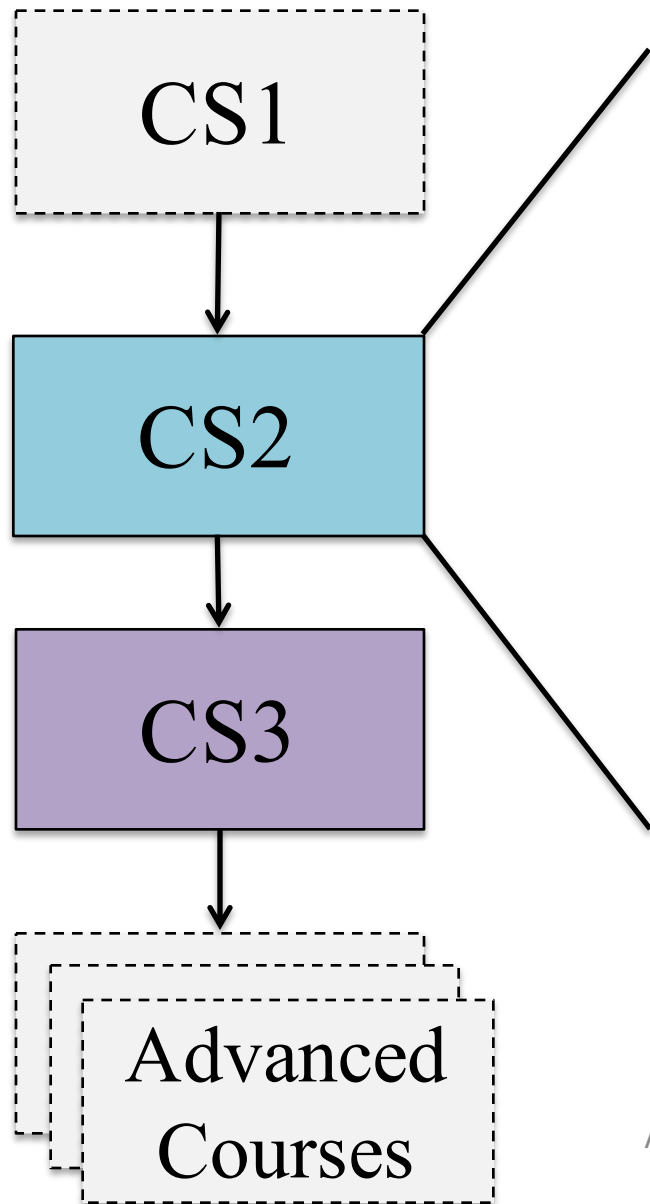
- Large research university
- 2,234 total students
- Consecutive courses
- Data set included:
  - Project scores
  - Exam scores
  - Partner status in CS2
  - Gender
  - Cumulative GPA

# Our Data Set

- 4 semesters of CS2
- 2 semesters of CS3
- Consistent curriculum across semesters

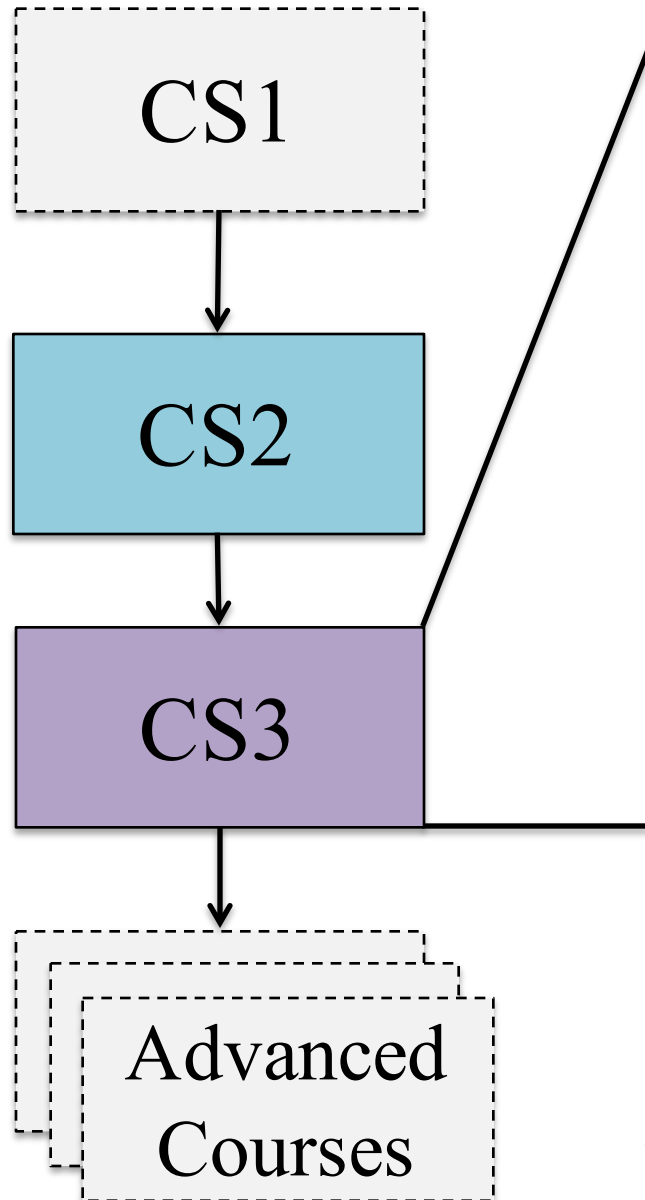


# Description of CS2



- Audience: prospective CS majors and minors
- Covers programming and intro data structures
- 2 exams, 5 projects
- Students have the **option to partner** on projects 2-5

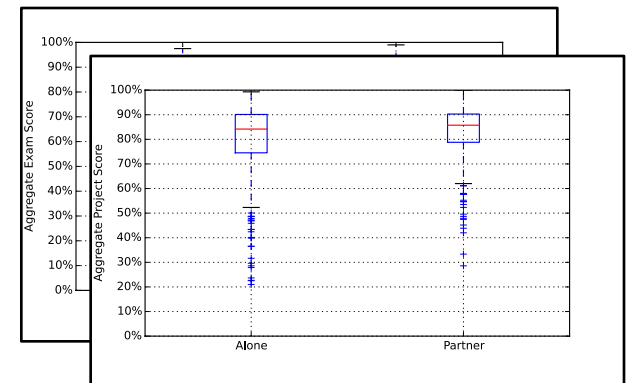
# Description of CS3



- Audience: prospective CS majors and minors
- Covers data structures and algorithms
- 2 exams, 4 projects
- Students must **work alone** on all projects

# Methods

- Compared sample means
- Statistical significance using student's t-test
- Partnership status: two subsets
  - Partnered, alone
- Gender groups: two subsets
  - Men, women
- GPA groups: four subsets
  - By quartile



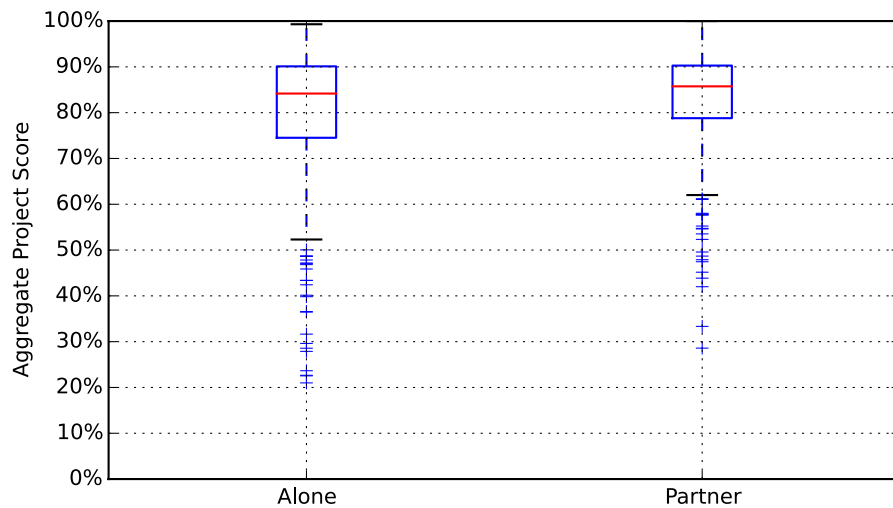
# Outline

- Introduction
- Methods and data set
- **CS2 results**
- CS3 results
- Discussion and conclusions

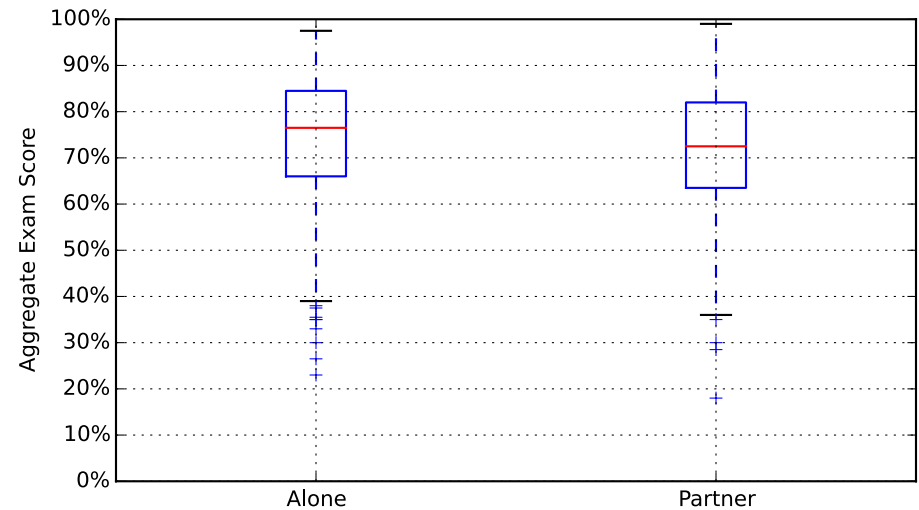
# Effects on CS2 general population

Evaluation	Partnered Mean (N)	Alone Mean (N)	Difference	p Value
Projects	83.3% (632)	80.0% (393)	3.3%	0.0001
Exams	71.8% (632)	74.6% (393)	-2.8%	0.001

Overall CS2 Performance



CS2 Project Scores



CS2 Exam Scores

# Effects on CS2 general population

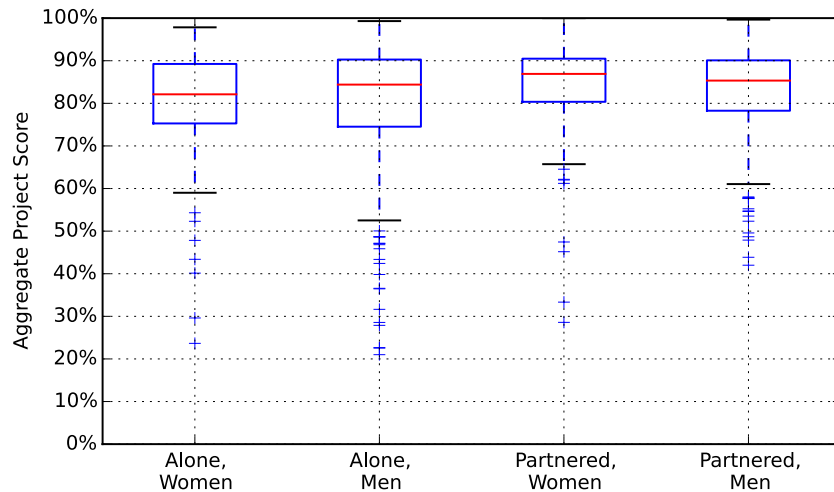
- Students who partnered tended to score better on projects
  - Consistent with the literature in Pair Programming
- Exam scores were lower when students choose to partner on projects in CS2
  - Several factors could influence this observation. For example, the instructors did not control team selection.



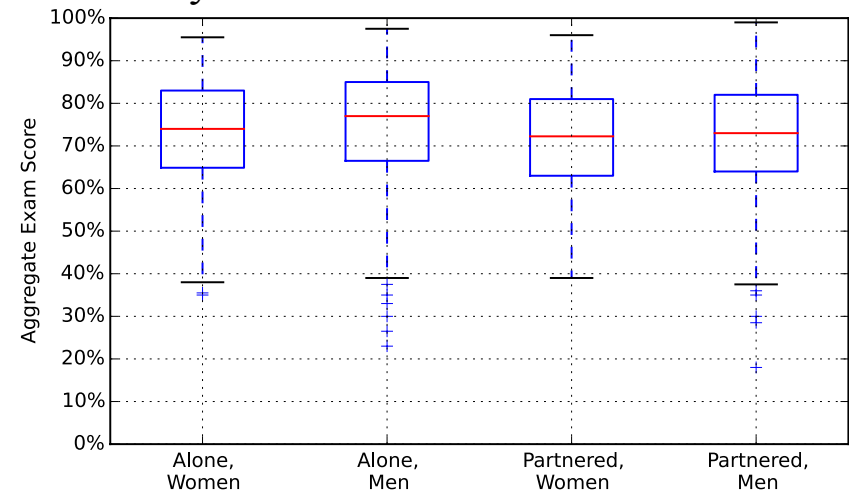
# Effects on CS2 by Gender

Evaluation	Gender	Partnered Mean (N)	Alone Mean (N)	Difference	p Value
Projects	Men	83.0% (473)	80.3% (305)	2.7%	0.005
	Women	84.1% (178)	79.1% (88)	5.0%	0.007
Exams	Men	72.0% (473)	75.2% (305)	-3.2%	0.001
	Women	70.9% (178)	72.5% (88)	-1.6%	0.388

Overall CS2 Performance by Gender



CS2 Project Scores by Gender



CS2 Exam Scores by Gender

# Effects on CS2 by Gender

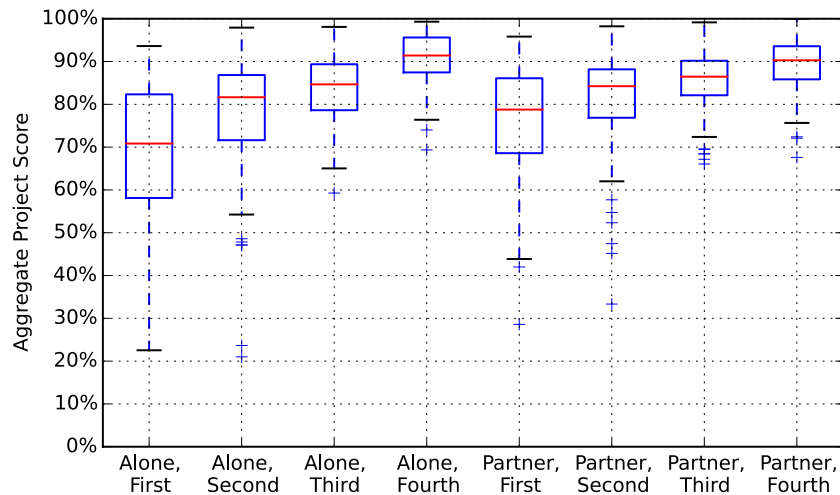
- Women had nearly double the benefit on projects of CS2 partnerships compared to men
  - Results consistent with the literature
  - Partnerships can be particularly beneficial to women in introductory computer science courses

# Effects on CS2 by GPA

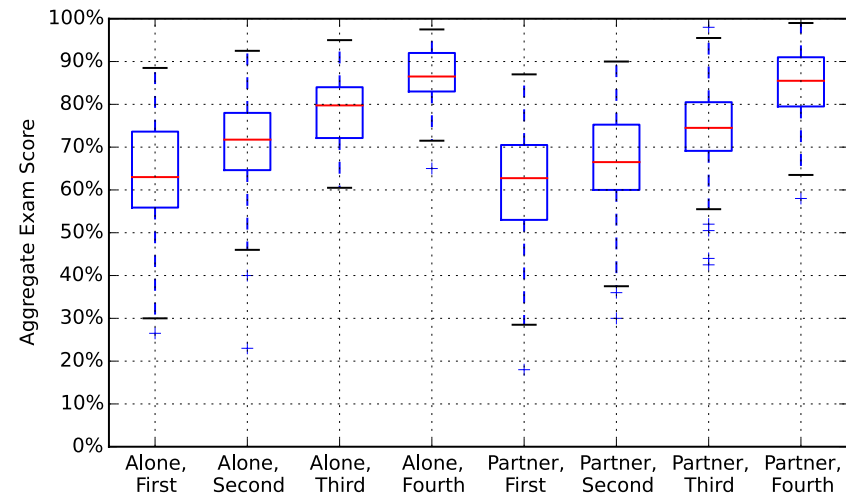
Evaluation	Quartile	Partnered Mean (N)	Alone Mean (N)	Difference	p Value
Projects	1st	76.6% (146)	67.8% (104)	8.8%	0.000021
	2nd	81.4% (179)	77.7% (86)	3.7%	0.033
	3rd	85.7% (154)	83.6% (98)	2.1%	0.022
	4th	89.5% (153)	90.6% (105)	-1.2%	0.095
Exams	1st	61.6% (146)	62.9% (104)	-1.3%	0.434
	2nd	66.9% (179)	70.2% (86)	-3.3%	0.031
	3rd	74.4% (154)	78.2% (98)	-3.8%	0.001
	4th	84.5% (153)	86.4% (105)	-1.9%	0.037

# Effects on CS2 by GPA

- We see that the associated benefit of partnerships for project scores increases with lower GPA



Overall CS2 Projects scores by GPA



Overall CS2 Exam scores by GPA

# Outline

- Introduction
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- **CS3 results**
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# Effects on CS3

Evaluation	Partnered Mean (N)	Alone Mean (N)	Difference	p Value
Projects	77.0% (312)	76.7% (195)	0.3%	0.867
Exams	62.7% (312)	64.6% (195)	-1.9%	0.153

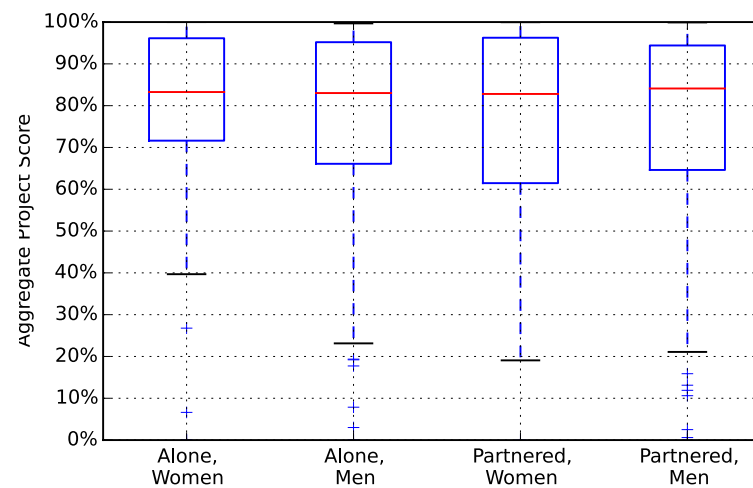
Overall CS3 Performance

- We could not make any statistically significant conclusions when looking at the impact of partnerships in CS2 on performance in CS3 within the general population

# Effects on CS3 by Gender

Evaluation	Gender	Partnered Mean (N)	Alone Mean (N)	Difference	p Value
Projects	Men	77.2% (244)	72.6% (155)	4.6%	0.023
	Women	76.7% (67)	69.3% (40)	7.3%	0.111
Exams	Men	62.9% (244)	64.6% (155)	-1.7%	0.110
	Women	61.9% (67)	60.9% (40)	1.0%	0.712

Overall CS3 Performance by Gender



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CS3 Projects Scores by Gender  
ASEL 2016

# Effects on CS3 by Gender

- Men who partnered in CS2 had a higher average project score in CS3 higher than those who had worked alone
- Other results were not statistically significant

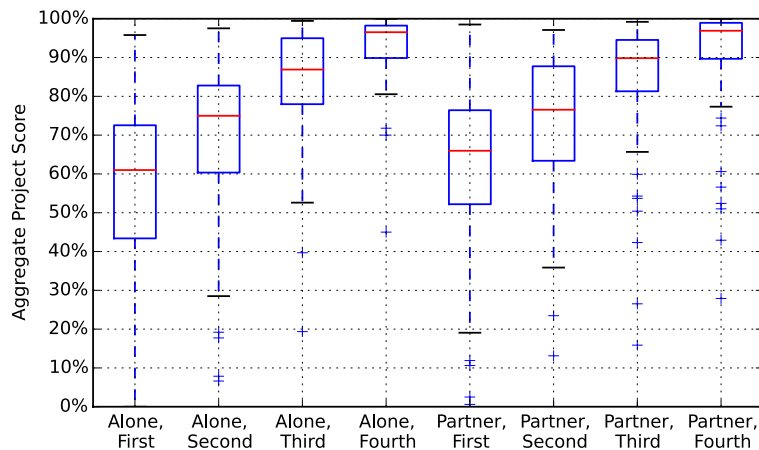


# Effects on CS3 by GPA

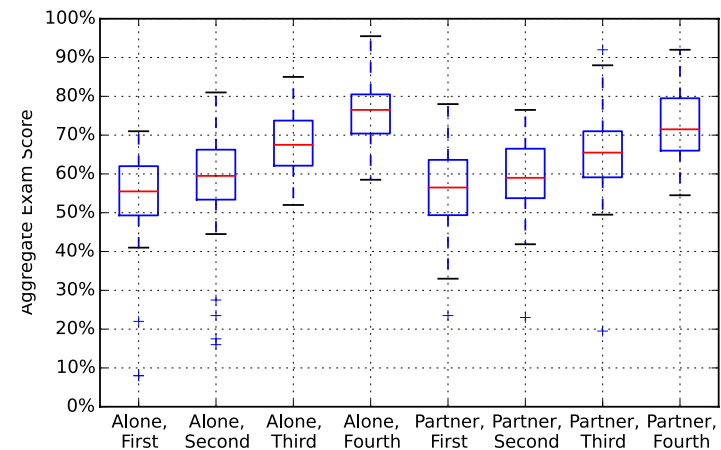
Evaluation	Quartile	Partnered Mean (N)	Alone Mean (N)	Difference	p Value
Projects	1st	60.4% (88)	51.2% (39)	9.2%	0.032
	2nd	71.0% (75)	66.2% (52)	4.8%	0.149
	3rd	81.7% (78)	77.7% (48)	4.0%	0.168
	4th	90.8% (71)	92.1% (56)	-1.3%	0.469
Exams	1st	55.2% (88)	55.6% (39)	0.04%	0.846
	2nd	57.4% (75)	58.2% (52)	-0.8%	0.669
	3rd	64.4% (78)	66.6% (48)	-2.0%	0.223
	4th	72.0% (71)	75.8% (56)	-3.8%	0.008

# Effects on CS3 by GPA

- Lowest GPA quartile associated with higher project scores in CS3 after partnering in CS2
- Highest GPA quartile associated with lower exam scores in CS3 after partnering in CS2



CS3 Project Scores by GPA



CS3 Exam Scores by GPA

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# Outline

- Introduction
- Methods and data set
- CS2 results
- CS3 results
- **Discussion and conclusions**

# Discussion

- Partnerships were mostly associated with increased project performance in both CS2 and CS3; especially among those in the lowest GPA quartile
- Working alone was mostly associated with higher exam scores in both CS2 and CS3; especially among those in the highest GPA quartile

# Limitations

- Students had the choice to partner on projects in their CS2 course
  - Also had choice of partner
- We had did not have control over group dynamics

# Conclusions

- Replicated prior work in pair programming during the same semester
- Both gender groups were associated with benefits from CS2 partnerships
  - Women more than men
- Students with lower GPAs were associated with the most benefits from partnering

# Conclusions

- Association between students in the lowest GPA quartile and higher CS3 project scores when partnering
- Did not observe any evidence of students performing poorly as a results of partnering