Understanding academic risk in interactive teaching environments

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Research Motivation

- Intellectual Problem
  - too few students succeed in early gateway courses; leads to attrition in disciplines and from institutions

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- Intellectual Problem
  - too few students succeed in early gateway courses; leads to attrition in disciplines and from institutions
- Research Problem
  - singular predictive factors of success in early college coursework not modeled at course-level
  - assumption that interactive teaching is panacea, when many students still at risk

Research Motivation

- Research Purpose
  - Predict barriers to success
  - Model early warning signs of academic risk

Theoretical Framework

- What are current barriers to success we can assess early in a course?
  - Prior knowledge (Dewey, Piaget, Vygotsky, Conley)
  - Perceived self-efficacy (Bandura)

Study Characteristics

- Physics 11b, Electricity and Magnetism for science and engineering majors
- 89 students, 41 female, 48 male
- Taught interactively using Peer Instruction

Definitions

- Peer Instruction
  - developed in 1990's by Eric Mazur
  - focuses on persistent engagement through guided conceptual questioning
  - employs response system (Learning Catalytics)
  - backed by empirical research

Definitions

- Success in gateway STEM courses
  - B or above

Definitions

- Success in gateway STEM courses
  - B or above
- Academic risk
  - Factors that contribute to final grade
    - Prior knowledge
    - Academic self-efficacy
    - Early homework scores
    - Mid-term exams
    - Peer Instruction Self-Efficacy

Peer Instruction Self-Efficacy

- Belief that you can convince your neighbor of your answer
- Belief you can defend your answer
- Belief in the clarity of your own answer

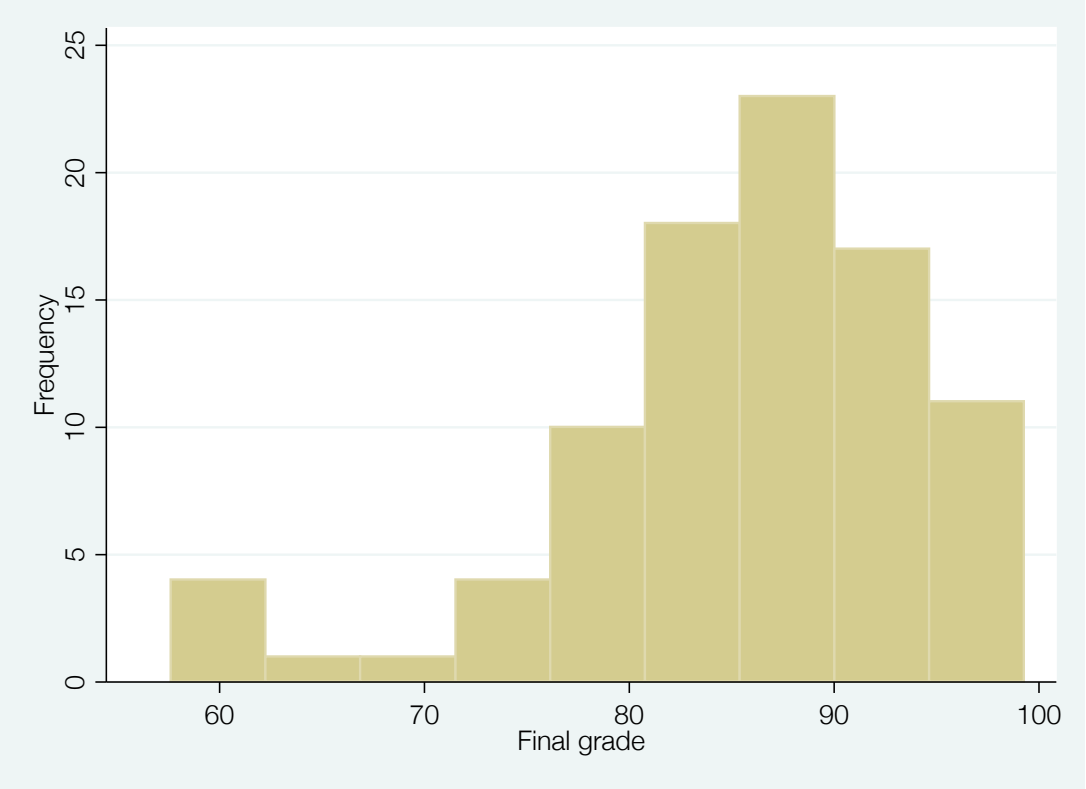
PISE Instrument

Peer Instruction Self-Efficacy Scale – Julie Schell and Brian Lukoff ©

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I have taught or tutored a class before	○	○	○	○	○
I enjoy learning about science	○	○	○	○	○
I enjoy learning about physics	○	○	○	○	○
I often do well in science courses	○	○	○	○	○
I often do well in non-science courses	○	○	○	○	○
I identify with students who do well on exams and quizzes in science courses	○	○	○	○	○
I expect to receive an A- or higher in this course	○	○	○	○	○
I am confident I can do the work required for this course	○	○	○	○	○
Doing laboratory experiments and write-ups comes easy to me	○	○	○	○	○
I am often able to help my classmates with physics in the laboratory or in section	○	○	○	○	○
I usually don't worry about my ability to solve physics problems	○	○	○	○	○
When I come across a tough physics problem, I work at it until I solve it	○	○	○	○	○
I get a sinking feeling when I think of trying to tackle difficult physics problems	○	○	○	○	○
I like hearing about questions that other students have about the reading	○	○	○	○	○
I am usually confident of my answers to the EARS questions before I talk to a neighbor	○	○	○	○	○
I am usually confident that I can convince my neighbor of my answer to EARS questions	○	○	○	○	○

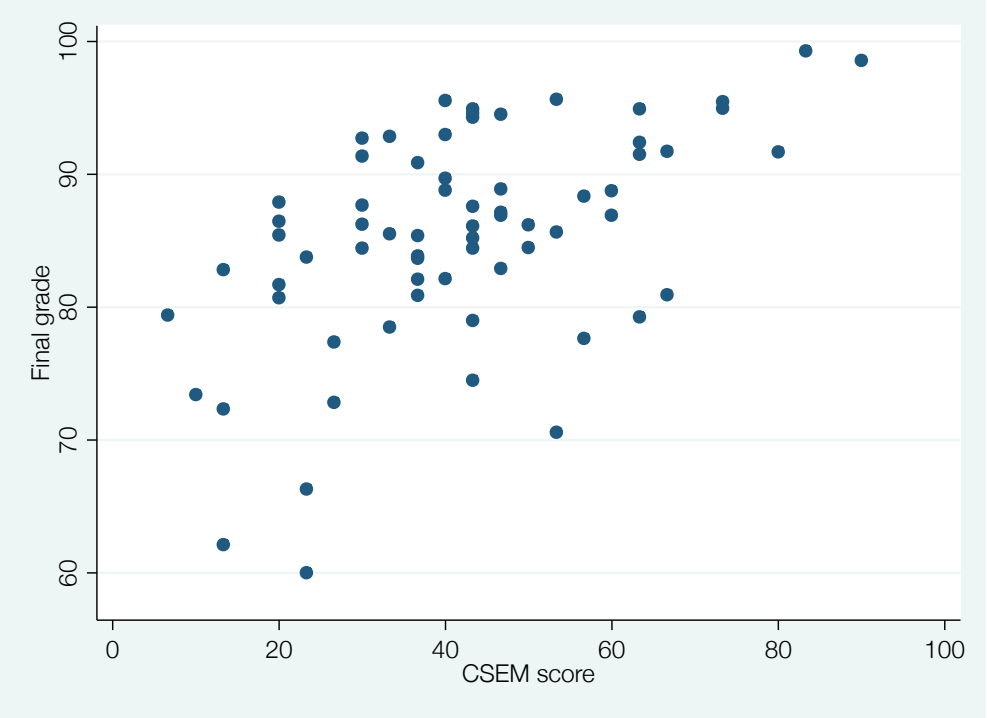
Results

- Want to be able to predict when a student is at risk of not succeeding



Results: Prior knowledge

- CSEM (Conceptual Survey of Electricity and Magnetism)



Results: Prior knowledge

	1
CSEM score	0.24***
R^2	0.29
RMSE	6.94

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results: Self-efficacy

- 7 items
- alpha = 0.85 (pre) and 0.83 (post)

Results: Self-efficacy (pre)

	1	2
CSEM score	0.24***	0.20***
Self-efficacy (pre)		2.89*
***R*²**	0.29	0.34
RMSE	6.94	6.7

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results: Peer Instruction Self-Efficacy

- **Peer Instruction Self-Efficacy:** A student's belief about their ability to productively participate in peer instruction
- Example questions
  - "I am usually confident that I can convince my neighbor of my answer to EARS questions"
  - "I can communicate science effectively"
- 8 items
- alpha = 0.66 (pre) and 0.73 (post)
- Not a significant predictor of final grades

Results: Peer Instruction Self-Efficacy

	1	2	3
CSEM score	0.24***	0.20***	0.20***
Self-efficacy (pre)		2.89*	3.34*
Peer-instruction self-efficacy (pre)			-1.11
R^2	0.29	0.34	0.35
RMSE	6.94	6.7	6.74

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results: Early problem sets

- Weekly problem sets
- First two problem sets completed by February 14

Results: Early problem sets

	1	2	3	4
CSEM score	0.24***	0.20***	0.20***	0.14**
Self-efficacy (pre)		2.89*	3.34*	3.39**
Peer-instruction self-efficacy (pre)			-1.11	
Early problem sets				0.83***
R^2	0.29	0.34	0.35	0.53
RMSE	6.94	6.7	6.74	5.7

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results: Midterm grades

- Midterms (hour-long, in-class exams) on February 17, March 11, and April 7

Results: Midterm grades

	1	2	3	4	5
CSEM score	0.24***	0.20***	0.20***	0.14**	0.07
Self-efficacy (pre)		2.89*	3.34*	3.39**	2.41*
Peer-instruction self-efficacy (pre)			-1.11		
Early problem sets				0.83***	0.57**
Midterm 1					0.64**
R^2	0.29	0.34	0.35	0.53	0.6
RMSE	6.94	6.7	6.74	5.7	5.3

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results: Midterm grades

	1	2	3	4	5	6
CSEM score	0.24***	0.20***	0.20***	0.14**	0.07	0.04
Self-efficacy (pre)		2.89*	3.34*	3.39**	2.41*	0.92
Peer-instruction self-efficacy (pre)			-1.11			
Early problem sets				0.83***	0.57**	0.34*
Midterm 1					0.64**	0.31
Midterm 2						0.81***
R^2	0.29	0.34	0.35	0.53	0.6	0.75
RMSE	6.94	6.7	6.74	5.7	5.3	4.25

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

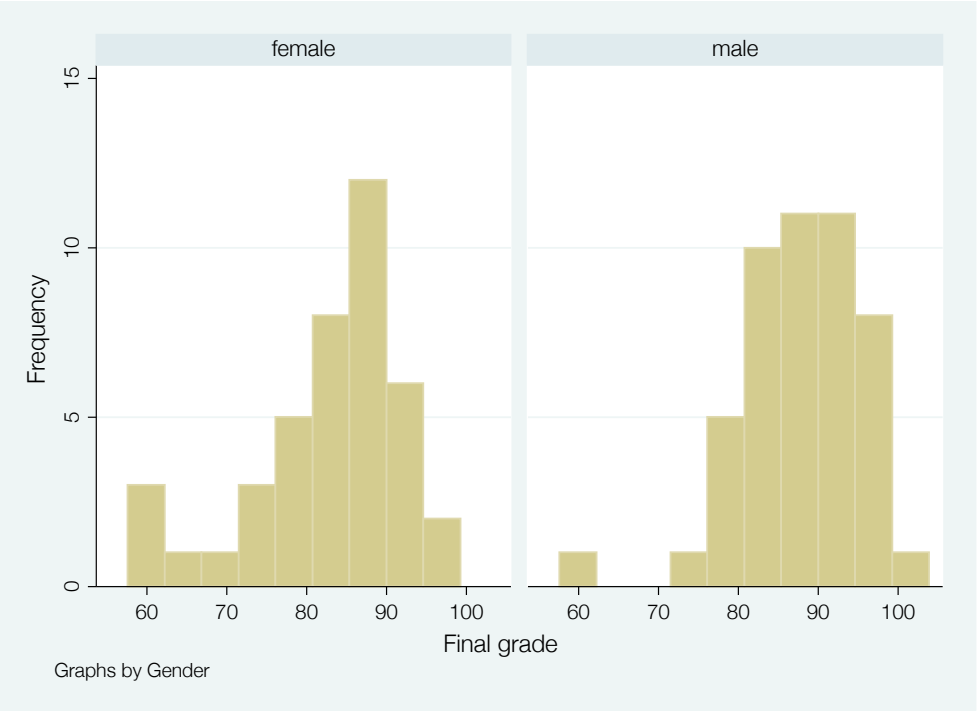
Results: Midterm grades

	1	2	3	4	5	6	7
CSEM score	0.24***	0.20***	0.20***	0.14**	0.07	0.04	0.04
Self-efficacy (pre)		2.89*	3.34*	3.39**	2.41*	0.92	0.4
Peer-instruction self-efficacy (pre)			-1.11				
Early problem sets				0.83***	0.57**	0.34*	0.30*
Midterm 1					0.64**	0.31	0.3
Midterm 2						0.81***	0.73***
Midterm 3							0.18*
R^2	0.29	0.34	0.35	0.53	0.6	0.75	0.77
RMSE	6.94	6.7	6.74	5.7	5.3	4.25	4.11

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Results: Investigating gender and academic success

- Males earn final grades on average 5% higher than females ($p < 0.05$)
- Women represent majority of lowest scoring students



Results: Investigating gender and academic success

- Among students with the same self-efficacy, both genders are statistically equivalent

Conclusions

- Pre-course readiness along content and non-cognitive dimensions predicts cumulative performance on a high-stakes marker
- Women are not succeeding in the ways we expect
- Early assessments of students' pre-course readiness along both dimensions may be a "game changer" for at-risk students

Future work

- Refining and testing the model using more classes
- Revising the PISE instrument
- Identifying other attitudinal measures that could help identify at-risk students
- Develop interventions to improve self-efficacy, especially for women
- Design systems to make early warnings available to instructors and students