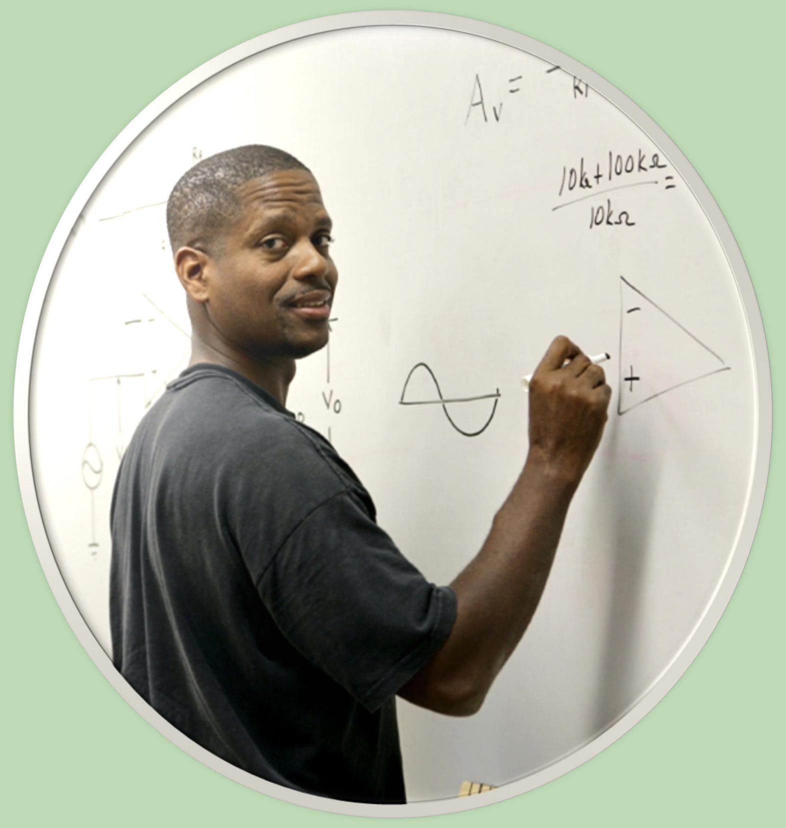


Crashing the Gate: Improving Student Learning in Introductory STEM Courses

Kevin Eagan, Sylvia Hurtado, and Felisha A. Herrera
Higher Education Research Institute, University of California at Los Angeles

Background

Relatively few students earn degrees in natural science or engineering in the U.S.
- 15% of U.S. bachelor's degrees are in science/engineering
- Compared to 67% in Singapore, 50% in China, 47% in France, 38% in South Korea

U.S. needs more undergraduate science majors to maintain achievement and innovation in science and engineering
- U.S. also needs to diversify the scientific workforce and increase representation of women and minorities

To graduate more bachelor's degrees in science, U.S. needs students to choose science majors and to maintain interest in science majors
- National increases in proportion of freshmen indicating interest in science, technology, engineering and math (STEM) majors
- Low proportion of students who intend to major in STEM actually graduate with STEM majors

"Gatekeeper" Courses

One Obstacle to STEM Major Completion

Mechanism for sorting students

First course in a series of courses in which knowledge is cumulative

Relatively high drop-out and failure rates in science gatekeeper courses
- Large lectures
- Highly competitive
- Un-engaging
- Grading on a curve

Classroom Environments & Instructor Pedagogies

Classroom climates impact learning and performance
- Competitive environments have a negative impact on learning, performance, retention, self-confidence

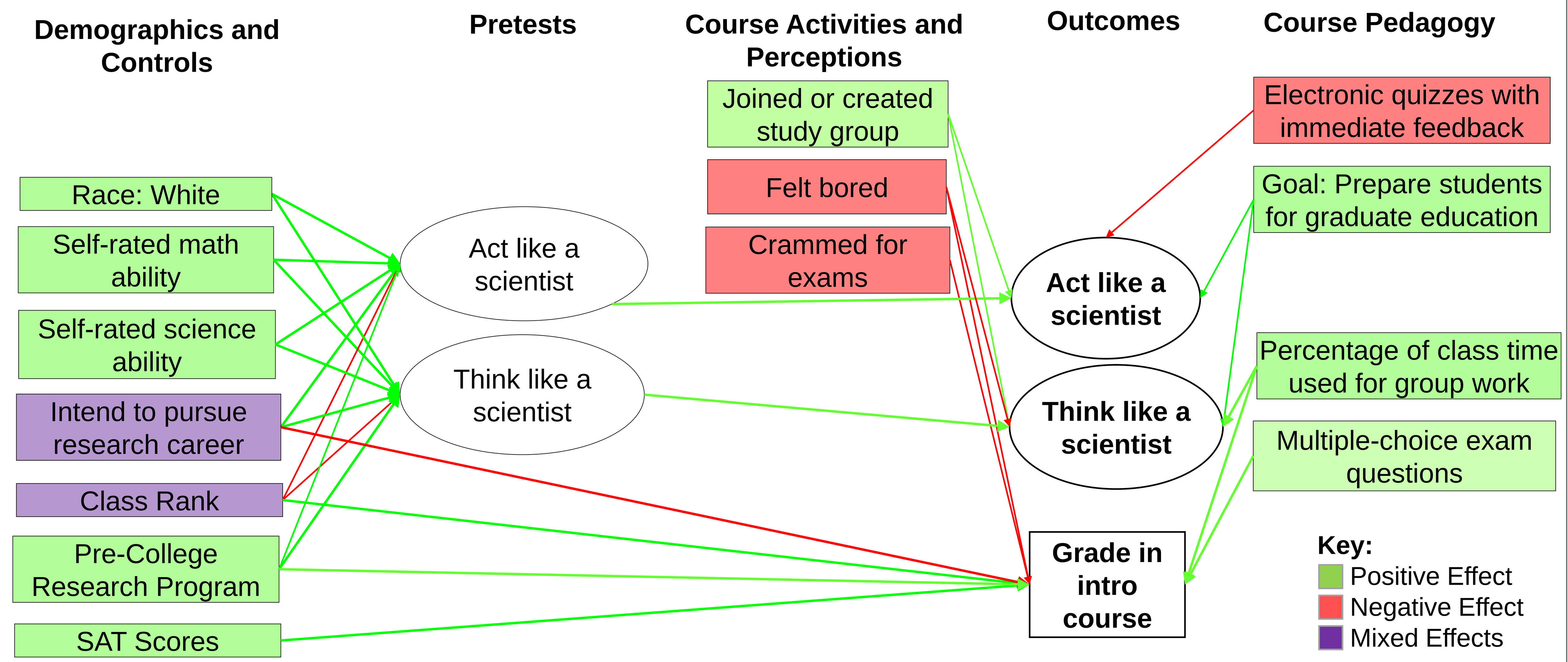
Collaborative environments that emphasize group work can mitigate negative effects of large lectures and competitive environments
- Can also promote critical thinking about scientific concepts and their applications

Supportive Learning Environments and the Skills Needed for Scientific Success

Six necessary conditions for a supportive learning environment:
- Quality of instruction, Teacher's interest, Social relatedness, Support of competence, Support of autonomy
- Engender greater self-motivation, encourages self-directed learning

Two primary pedagogical techniques in science
- Domain-specific learning = memorization of facts and causal relationships
- Domain-general learning = reasoning strategies and critical thinking skills

Structural Equation Model



Key Direct Effects

Initial Score of Acting and Thinking like a Scientist:
- Prior academic achievement, as measured by class rank (-)
- Self-rated science and math ability (+)
- Intent to pursue a research career (+)
- Tutoring another student in high school

End-of-Term Score of Acting like a Scientist:
- Joined or created a study group (+)
- Had professor who frequently used electronic quizzes (-)
- Had professor who wanted to prepare students for graduate education (+)

End-of-Term Score of Thinking like a Scientist:
- Joined or created a study group (+)
- Frequently felt bored in class (-)
- Had professor who wanted to prepare students for graduate education (+)
- Had professor who utilized more class time for group work (+)

End-of-Term Course Grade:
- Prior academic achievement: class rank and SAT scores (+)
- Pre-college research program (+)
- Crammed for exams (-)
- Felt bored (-)
- Had professor who used more class time for group work (+)

Key Indirect Effects

Thinking and Acting like a Scientist:
- Aspiring to a research career and participating in a pre-college research program (+)
- Self-rated math and science abilities (+)
- Class rank (-)

Thinking and Acting like a Scientist

	Pre-Test	Post-Test
Thinking like a Scientist		
Make connections between different areas of science and math	0.67	0.70
Make sense of scientific concepts	0.71	0.72
Identify what is known about a problem	0.63	0.63
Ask relevant questions	0.60	0.64
Draw a picture to represent a problem or concept	0.46	0.51
Make preditions based on existing knowledge	0.69	0.71
Come up with solutions to problems and explain them to others	0.67	0.72
Investigate alternative solutions to a problem	0.67	0.68
Translate scientific terminology into non-scientific language	0.57	0.62
Activing like a Scientist		
Relate scientific concepts to real-world problems	0.71	0.75
Synthesize several sources of information	0.70	0.70
Conduct an experiment	0.54	0.54
Look up scientific research articles and resources	0.59	0.57
Memorize large quantities of information	0.41	0.44

Project Team

Sylvia Hurtado, Co-Principal Investigator
Mitchell Chang, Co-Principal Investigator

Kevin Eagan, Postdoctoral Research Fellow
Josephine Gasiewski, Postdoctoral Research Fellow

Aaron Pearl, Administrative Specialist
Monica H. Lin, Public Admin. Analyst

Christopher B. Newman, Research Analyst
Jessica Sharkness, Research Analyst
Minh Tran, Research Analyst
Juan Garibay, Research Analyst
Gina Garcia, Research Analyst
Cindy Mosqueda, Research Analyst
Felisha Herrera, Research Analyst
Tanya Figueroa, Research Analyst

For Further Information

herinih@ucla.edu
http://www.heri.ucla.edu/nih

POST-BACCALAUREATE EXPERIENCES, SUCCESS, & TRANSITION

Analytic Strategy

Data
- STEM Student pre- and post-questionnaire
  - 15 campuses, 90 classrooms
  - 3,205 longitudinal student responses
- STEM Faculty Survey
  - 15 campuses, 90 classrooms
  - 76 faculty responses

Variables
- Outcomes: Course grades, frequency of thinking like a scientist, frequency of acting like a scientist
- Predictors: demographics, self-rated abilities, prior academic achievement, course behavior, faculty pedagogy

Analysis
- Confirmatory factor analysis
- Structural equation modeling in EQS

Conclusions and Implications

- **Prior academic achievement** was strongest predictor of course grades
- Students' **gains in thinking and acting** like scientists had **no significant correlation** with their **final grade** in their introductory course
- **Last-minute studying for exams negatively related to students' final grades** in the course but had no relationship with the frequency with which they reported thinking and acting like scientists
- Students in courses where instructors have a **long-term goal of preparing students for future educational endeavors tended to have stronger gains** in thinking and acting like scientists
- Students in courses where instructors spent more course time utilizing **group activities reported significantly higher gains in thinking like a scientist and higher course grades**
- Findings suggest faculty have an opportunity **to adjust grading practices** to reflect **learning rather than just students' prior preparation**