

# Assessing Scientific Inquiry and Leadership Skills (AScILS) COSMOS Board Meeting July 24, 2008

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## Our Appreciation

COSMOS Board of Directors

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Rena Dorph

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## Overarching Research Questions

- How do activities implemented by biomedical research career support programs (especially research and mentoring) influence:
  - Scientific research skills,
  - Science team leadership and membership skills,
  - Beliefs in efficacy and collective efficacy regarding these skills,
  - Identity as a scientist, and
  - Stage-appropriate educational and career outcomes?
- Are these influences similar for minority and non-minority students?

## Self-Efficacy

“The belief in one’s abilities to organize and execute courses of action required to produce given attainments.”

(Bandura, 1997, p. 3)

## Efficacy Beliefs Influence:

- Choice of courses of action
- Amount of energy expended
- Perseverance and resilience in the face of challenges and failures

## Mediating Processes of Efficacy Beliefs

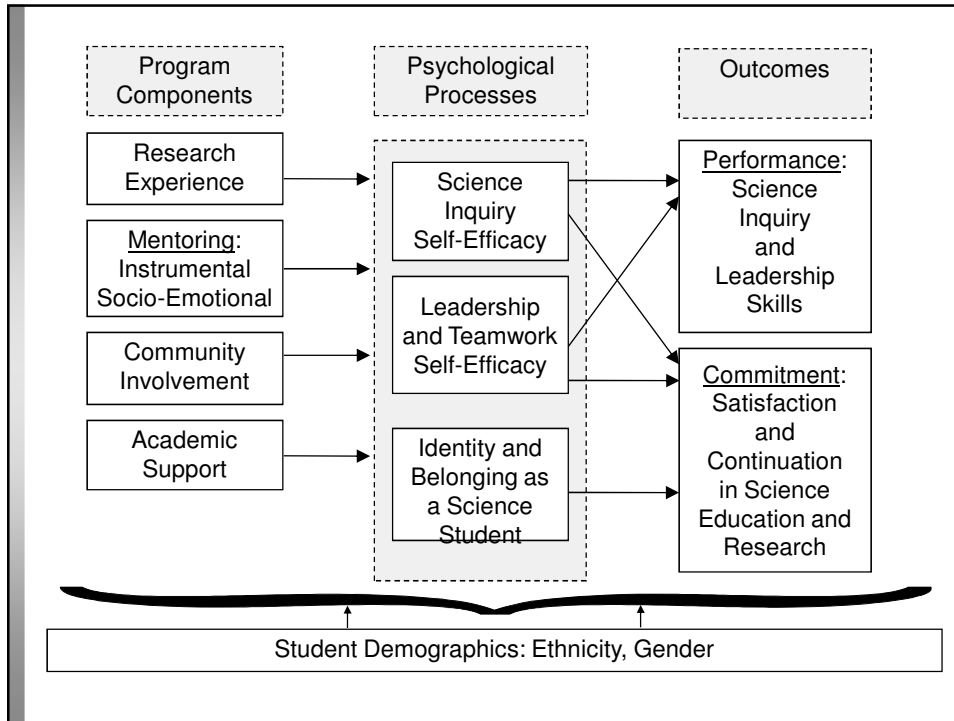
- Cognition
  - Analytic complexity
  - Strategic planning
- Motivation
  - Goal setting
  - Self-regulation
- Emotion
  - Calmness
  - Challenge vs. threat appraisals

## Sources of Self-Efficacy

- Enactive Mastery
- Vicarious Role Modeling
- Social Persuasion
- Affect/Emotion

## Identity as a Science Student

- The subjective perception of membership in a group of others who have some characteristic(s) in common
- Based on
  - Ascribed characteristics (e.g. ethnicity, gender)
  - Achieved states (e.g. occupation)
- A sense of comfort or belonging, a good fit between the self and the social group



## Example Items: Program Components

- |                            |  |
|----------------------------|--|
| Research Experience        | <ul style="list-style-type: none"> <li>• Outside of coursework, I ... <ul style="list-style-type: none"> <li>– Worked as a member of research team</li> <li>– Figured out what data/observations to collect</li> </ul> </li> </ul> |
| Mentoring: Instrumental    | <ul style="list-style-type: none"> <li>• Mentors have ... <ul style="list-style-type: none"> <li>– Given challenging assignments</li> <li>– Helped me figure out how to answer a research question</li> </ul> </li> </ul>          |
| Mentoring: Socio-Emotional | <ul style="list-style-type: none"> <li>• Mentors have ... <ul style="list-style-type: none"> <li>– Conveyed empathy for my concerns</li> <li>– Served as a role model</li> </ul> </li> </ul>                                       |

## Example Items: Program Components

Community  
Involvement

- Outside of coursework, I ...
  - Networked with fellow students
  - Received advice about personal issues such as roommates

Academic  
Support

- Outside of coursework, I ...
  - Attended workshops to improve science or math achievement
  - Received tutoring help

## Example Items: Psychological Processes

Science  
Inquiry  
Self-Efficacy

- “I am confident I can...”
  - Use technical science skills
  - Use scientific literature to guide research

Leadership  
and Teamwork  
Self-Efficacy

- I am confident of my ability to influence a team I lead.
- I know how to cooperate effectively as a member of a team.

Identity and  
Belonging as  
a Science  
Student

- I have a strong sense of belonging to the community of science or mathematics students.
- I am a science or mathematics student.

## Example Items: Outcome

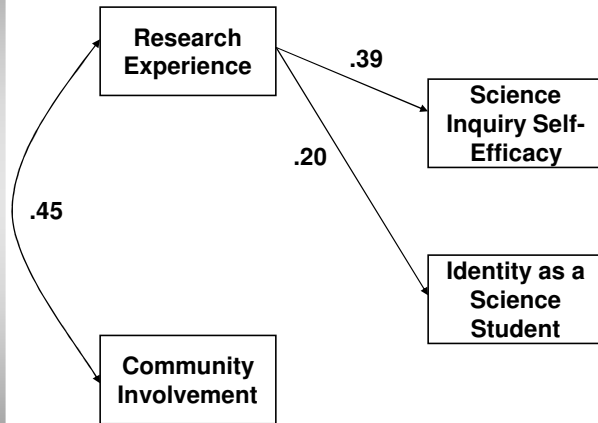
Commitment:  
Satisfaction  
and  
Continuation  
in Science  
Education and  
Research

- I intend to work in a job related to science or mathematics.
- I will work as hard as necessary to achieve a career in science or mathematics.

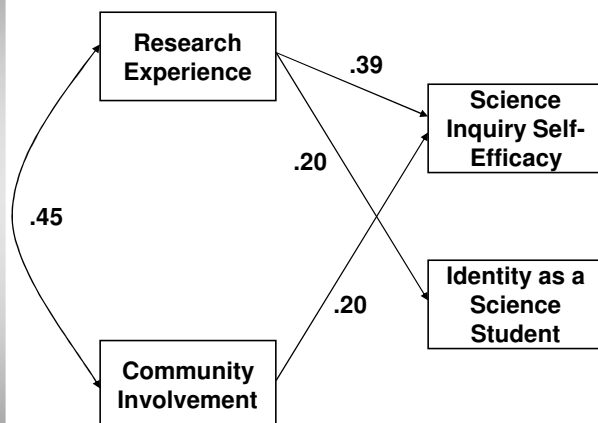
## Participant Demographics

- Recruited from UCSC COSMOS program in 2006 and 2007
- $N = 276$  participants with complete data (95% of all attendees)
- 56% Female
- Ethnicity:
  - 26% Under-Represented Minority
  - 36% White
  - 38% Asian
- 38% Received financial aid

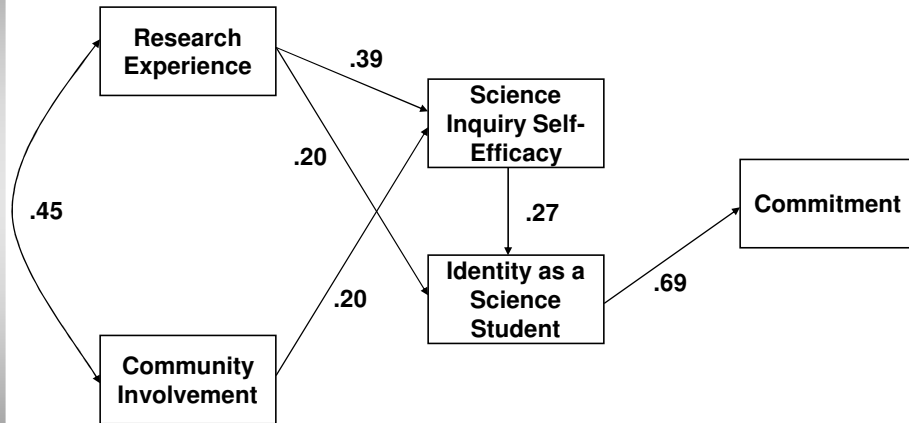
## COSMOS Longitudinal Study: Pre-Program Results



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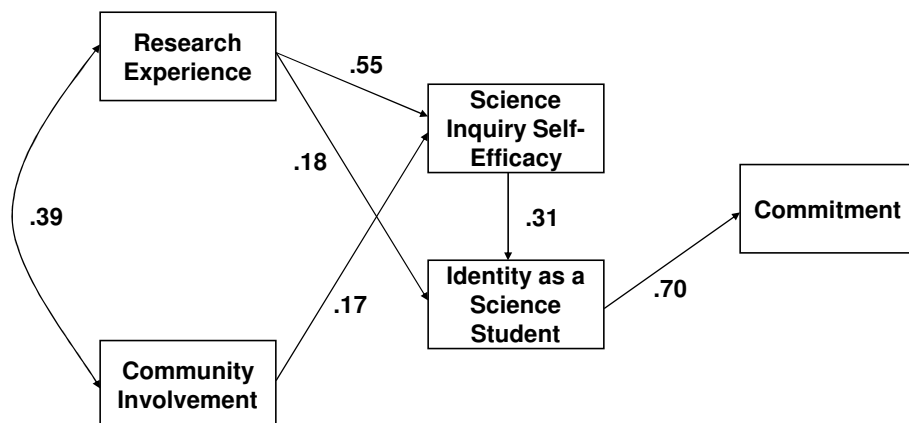


## COSMOS Longitudinal Study: Pre-Program Results



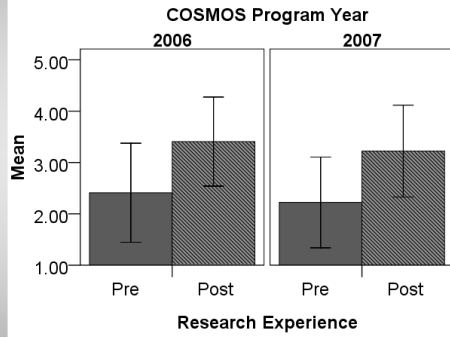
Model Fit:  $\chi^2 (4) = 4.19, p = .38, CFI = 1.0, IFI = 1.0, GFI = .99,$   
 $NNFI = .99, RMR = .02, RMSEA = .01 (.00, .09)$

## COSMOS Longitudinal Study: Post-Program Results

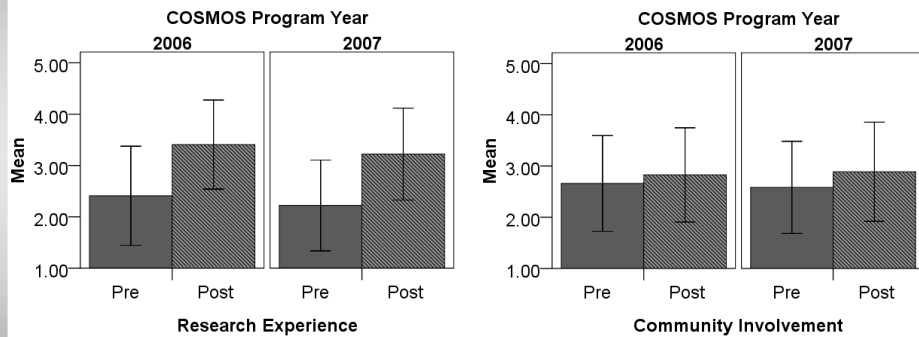


Model Fit:  $\chi^2 (4) = 11.88, p = .02, CFI = .98, IFI = .98, GFI = .98,$   
 $NNFI = .96, RMR = .03, RMSEA = .08 (.03, .14)$

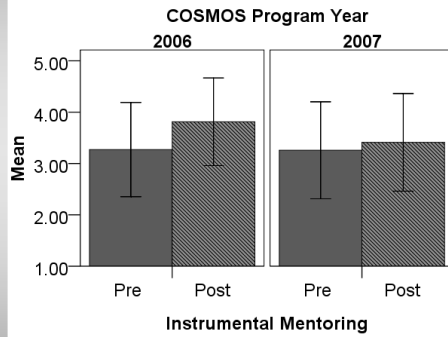
## Pre- and Post-Program Scores on Central Variables



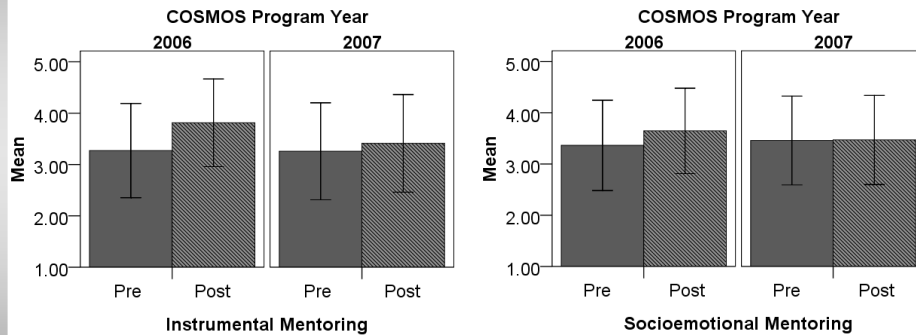
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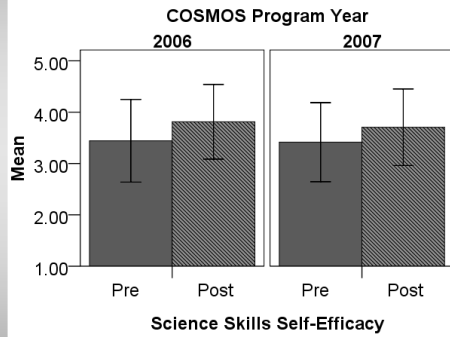
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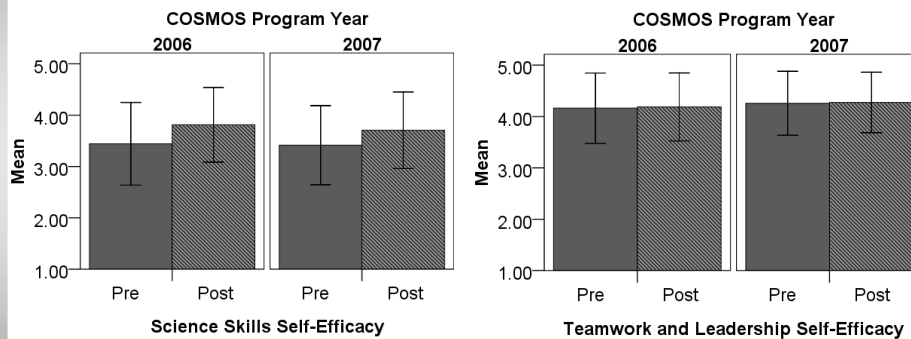
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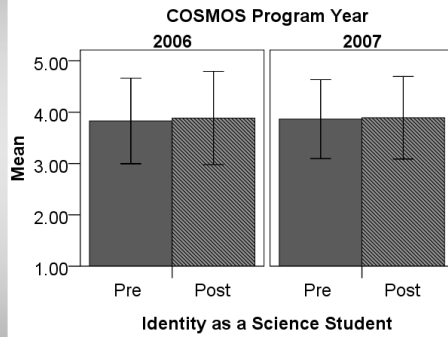
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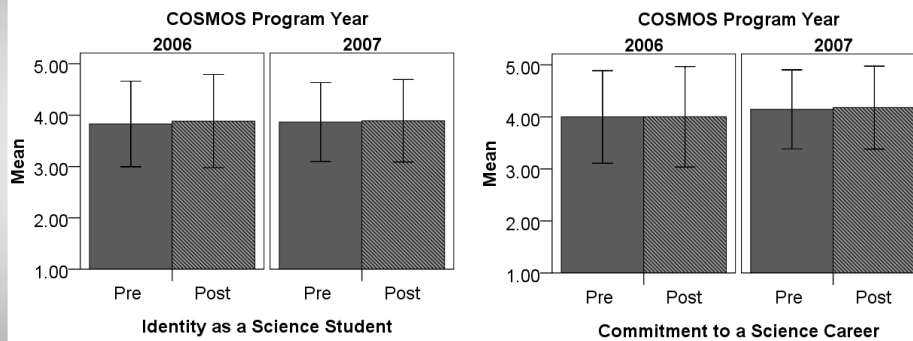
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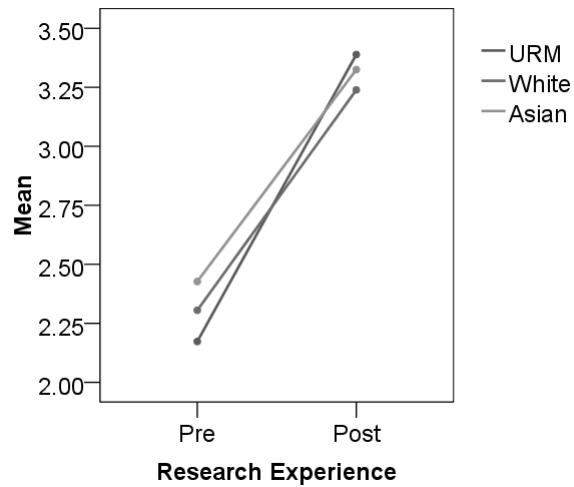
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## Ethnic Group Comparisons on Pre- to Post-Program Change



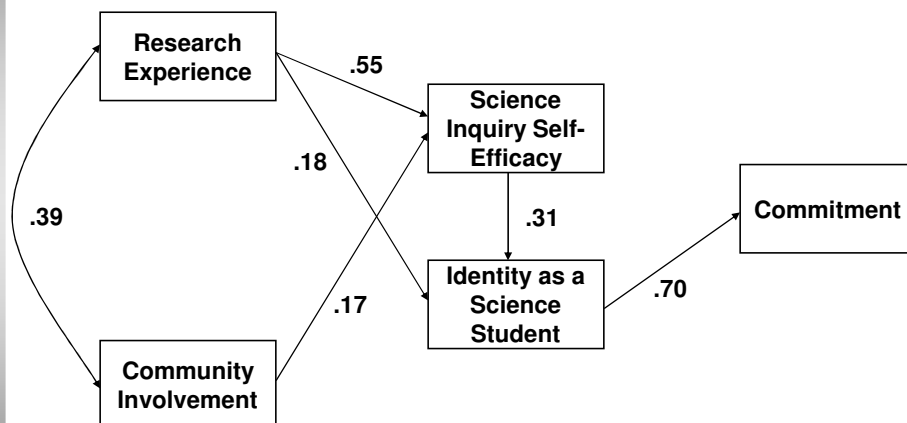
## Ethnic Group Comparisons on Pre- to Post-Program Change



## In Students' Own Words

- From COSMOS 2007 participants' responses
- Prompt: Please take a few minutes to tell us about a time you remember thinking “I enjoy science” or “I enjoy mathematics.”
- 140 participants responded, with an average of 1.48 different comments per student

## COSMOS Longitudinal Study: Post-Program Results



## Doing Science

- Students reported enjoying experiments, labs (n=43, 31%)
- “I liked an experiment we did in Biology where we got to design our own controlled experiment. We got to decide how to test it and collect the data and observations. I learned a lot and also enjoyed doing it.”
- “When we made oobleck in Chemistry and debated whether it was solid or liquid. It made me realize nothing is really absolute in science, and that made it fun.”

## Doing Math

- Students enjoyed solving proofs, puzzles (n=25, 18%)
- “I liked deriving chunky trigonometry equations b/c I liked the satisfaction of seeing both sides boil down to the same thing.... I’ve always liked solving patterns.
- “I enjoy mathematics because there are right and wrong answers and it cannot be disputed. I enjoy science because I am able to apply mathematics to it.”

## Link Between Research, Self-Efficacy, and Identity

- “....the last time when I was working in the lab & felt like I was actually creating something original. I think that’s the best part about being a scientist, as well as how everything falls together with enough logic and analysis.”

## Community Involvement

- “Every time I see a nerd cartoon Everytime I’m with other math/science nerds who share nerd jokes or say ‘your redshifting’ if I walk too slowly.”
- “I went to the Maker Fair.... There were a lot of cool gizmos and gadgets and experiments and exhibits and the like. I thought to myself, ‘I love being a nerd!’  
**NERDS RULE!**”

## Link Between Community Involvement and Self-Efficacy

- Students commented on teachers (n=12, 9%) and peers (n=5, 4%)
- “....I was reading over my lectures about linear algebra and being utterly confused. Then, I kept reading over and over and asking questions of my friends and teachers.... Finally understood, and afterwards I was excited to learn more about math.”

## Mastery

- Students commented on general self-affirmation (n=18, 13%) and challenge (n=23, 16%)
- “I remember thinking I enjoy math when there was a topic my teacher started talking about trigonometry I didn't get it but I kept working on it until in the end I understood and felt satisfied and I felt I could understand anything only if I really take the time to learn it and practice it.”

## Emotions

- Students reported positive emotional reactions to the content or process of math/science (n=36, 26%)
- “In middle school we had to do a report on the solar system. My topic was the milky way. I remember, as everyone presented their reports and acted bored, I wondered why it was so interesting to me. I just sat back and listened, and was interested and thought “I love science.”

## Social Persuasion

- Students commented on recognition, awards (n=11, 8%)
- “...When I figured out how to calibrate a TAC yesterday. I felt accomplished. I especially felt that way after [prof] shook my hand.”

## COSMOS

- Specific references to COSMOS (n = 45, 32%)
- “I’m not a good science or math student. It’s never been something I’ve wanted to specialize in. I enjoyed science here at COSMOS. Every day there was something new to do and learn and think about. I have never been given a chance to look at science that way.”

## Commitment

- Students commented on increased M/S career interest (n=5, 4%)
- “The entire COSMOS experience has made me enjoy math and science even more than I had before. The opportunities presented to us and the insight from the many down to earth professors at UCSC has helped me to further finalize what I would like to see myself doing in the future.”

## Sometimes it's not a fit

- "...I don't enjoy math and science as much as a COSMOS student should.... I enjoy humanities.... I have enjoyed math and science while at COSMOS. A lot. But I don't think I would enjoy having a lot more to do with it."

## What's Different About COSMOS

- "The only time I remember actually enjoying science was COSMOS. I felt like I'm not being forced to learn but I was there willingly to learn still. At school it felt everything revolved around taking a test and it didn't really matter if I was learning anything. At COSMOS we did labs and learned how to synthesize esters... from scratch which felt really rewarding."

## Implications for Research

- Reliable measures are useful in hypothesis testing and (potentially) in evaluating activities
- Theoretical model predicts students' career intentions; follow up research needed:
  - Students' career behaviors
  - Sources of self-efficacy
  - Teacher fellows' enhanced self-efficacy re science education, shifts in classroom behaviors

## Implications for Practice and Policy

- COSMOS interventions are useful
  - Expansion possibilities?
- A focus on psychological processes might strengthen those interventions
  - Professional development opportunities?
- Embedding more science in the classroom:
  - What's got to give?

## AScILS Research Team

- Martin Chemers, PI, Psychology
- Faye Crosby, Psychology
- Barbara Goza, Educational Partnership Center
- Lisa Hunter, Center for Adaptive Optics
- Beth Jaworski, Psychology
- Deborah Kogan, Evaluation Consultant
- Carrol Moran, Educational Partnership Center
- Elizabeth Morgan, Psychology
- Julie Shattuck, Evaluation Consultant
- Kristina Schmuckler, Psychology
- Jerome Shaw, Education
- Moin Syed, Psychology
- Eileen Zurbriggen, Psychology
- Former members: Lisa Algee, Steve Bearman, Melissa Bayne, Elizabeth Espinosa, Julian Fernald, John Johnson, Stephen Mello, Refugio Rochin, Gloria Williams, and 15 undergraduates

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