Characteristics of Successful Programs In College Calculus

A report on our findings

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PowerPoint available at
www.macalester.edu/~bressoud/talks

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MAA Study of Calculus

Characteristics of Successful Programs in College Calculus

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Phase I: Survey

1. Institutional questionnaire, chair
2. Calculus coordinator questionnaire
3. Instructor pre-term survey
4. Student 2nd to 3rd week survey
5. Student 2nd to 3rd last week survey
6. Instructor post-term survey
7. Collection of final exams and grades

Initial survey responses from

168 colleges and universities

660 instructors representing almost 900 Calculus I classes and over 34,000 students

14,000 students

55% men

97% full-time students

75% freshmen

76% White, 14% Asian, 5% Black, 10% Hispanic

Total college population: 73% White, 9% Asian, 12% Black, 12% Hispanic

75% intend to major in Science or Engineering

(Bio 30%, Eng 30%, Phys Sci 6%, CS 5%)

61% all Calculus I students took a calculus class in high school. 61% of them earned an A (37% of all Calc I students)

For 69% of those took took Calc in HS, it was an AP Calculus course (42% of all Calc I students).

81% of the AP Calculus students took the AP exam (34% of all Calc I students)

60% of those who took the exam earned a 3 or higher (just over 20% of all Calc I students)

These are good students:

- Average SAT Math: 652, standard deviation = 76, Interquartile range [610,700]
- 95% believe they have knowledge and abilities to succeed in calculus
- 89% find using reasoning to solve math problems a satisfying experience
- 83% enjoy mathematics
- 65% would be taking this course even if it were not required

They want to understand calculus:

74% prefer to make sense of the mathematics rather than simply memorizing it

72% see the role of the instructor as helping students to reason through problems on their own rather than showing students how to work the problems

58% expect to earn an A in this course

Grade for college Calculus I:

22% A

28% B

23% C

27% D, F, or Withdrew

Comparison of start of term and end of term surveys

Statistical analysis by

Phil Sadler Gerhard Sonnert

Harvard University

Dependent Variables

Pre- and post-term surveys:

- I am confident in my mathematical abilities
- If I had a choice, I would continue to take mathematics
- I enjoy doing mathematics
- I intend to take Calc II

Post-term survey only:

- This course has increased my interest in taking more mathematics

Selection Bias

While the grade distribution of all students (as reported by instructors) was

A: 22%, B: 28%, C: 23%, DFW: 27%

For those who completed both surveys, it was

A: 38%, B: 39%, C: 19%, DFW: 4%

Control Variables

- Demographics
  - Gender, SES, Race/Ethnicity
- HS Math
  - Math courses taken; if calculus, what kind; if AP exam, which and what score
  - Grade in last HS math course
  - SAT/ACT scores
- College
  - Prior college math, year in college, career intention
  - Pre-term survey value

Independent Variables

Student supplied:

- Student beliefs and attitudes about learning mathematics
- Study habits
- Level of intellectual engagement with the course
- Experience with technology (graphing calculators and/or computer software)

Independent Variables

Student supplied:

- Student perceptions of instructional practices
- Student perceptions of instructor use of technology
- Student perceptions of assessment practices
- The intellectual community outside of class

Independent Variables

Instructor supplied:

- Class size
- Instructor experience and background
- Instructor beliefs, attitudes, and interests
- Assessment practices
- Out of class interactions with students
- Use of technology including use of web resources
- Textbook as well as additional instructional resources provided for students

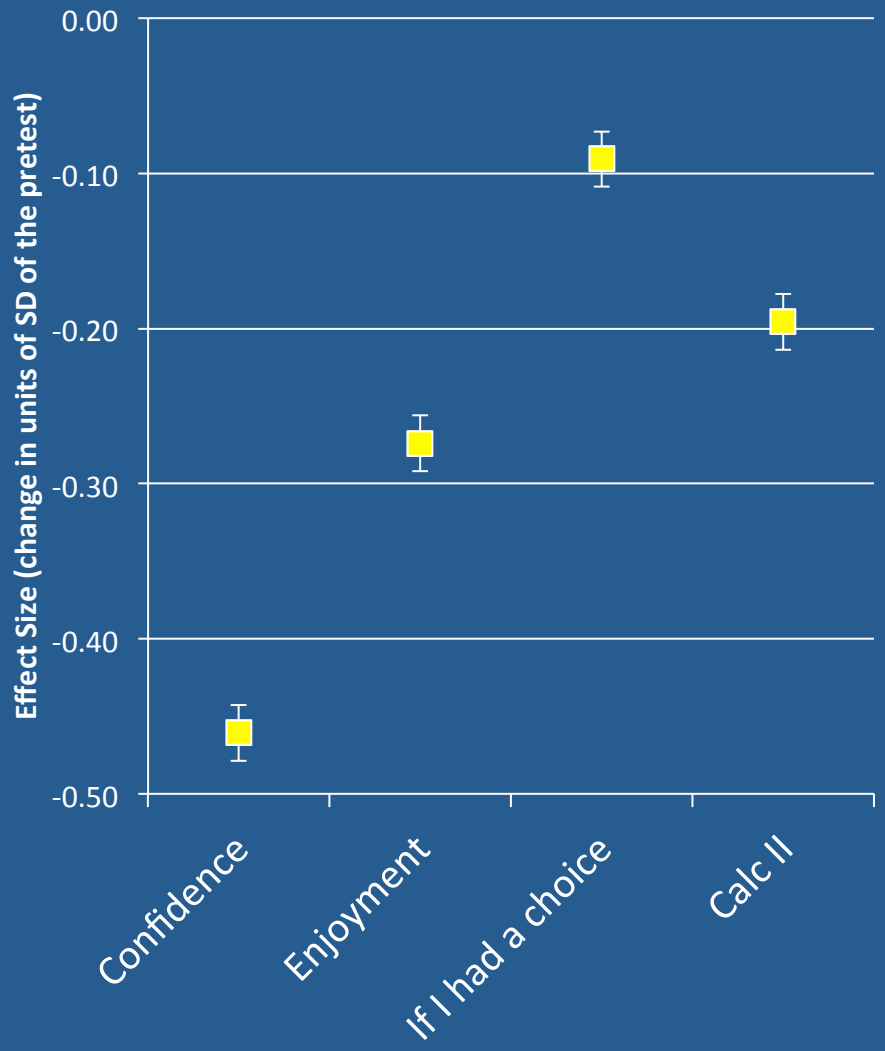
Independent Variables

Coordinator supplied:

- Placement procedures
- Technological support
- Institutional support for students
- Institutional support for instructors

Dependent Variables

Variable	Mean	SD	SE	Δ	ES
Confidence	3.89	1.01	0.02		
	3.42	1.18	0.02	-0.47	-0.46
Enjoyment	3.63	1.27	0.02		
	3.28	1.37	0.02	-0.35	-0.27
If I had a Choice…	1.93	1.02	0.02		
	1.84	1.08	0.02	-0.09	-0.09
Calc II	0.81	0.33	0.01		
	0.74	0.44	0.01	-0.07	-0.20



Hierarchical Linear Model

81% of variance can be explained by student-level variables

Pre-term survey value was the greatest single predictor of post-survey value.

Science majors did better, effect sizes of

- 0.52*** on increased interest in math
- 0.28*** on enjoyment
- 0.25*** on desire to take more math
- 0.19* on confidence

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

Being male had a large effect size:

0.60*** on continuing to Calculus II

0.39*** on increased interest in math

0.17*** on confidence

0.11* on desire to take more math

Taking AP Calculus had a large effect size:

0.31*** on confidence if AB Calculus

0.41*** on confidence if BC Calculus

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

Hierarchical Linear Model

16% of variance is at the institutional level

UC San Diego *raised* student confidence with an effect size of 0.4.

$p = 0.029$

“Technology*”

Instructor use of technology in the classroom

Student use of technology in the classroom

Student use of technology on assignments

Student use of technology on exams

*Use of technology included questions about Graphing Calculators, Computers, Computer Algebra Systems, Clickers, and Online Homework Systems

Not significant

“Good Teaching”

My Calculus Instructor:

- listened carefully to my questions and comments
- allowed time for me to understand difficult ideas
- presented more than one method for solving problems
- asked questions to determine if I understood what was being discussed
- discussed applications of calculus
- encouraged students to seek help during office hours
- frequently prepared extra material

Assignments were challenging but doable

My Calculus exams were a good assessment of what I learned

$p < 0.001$

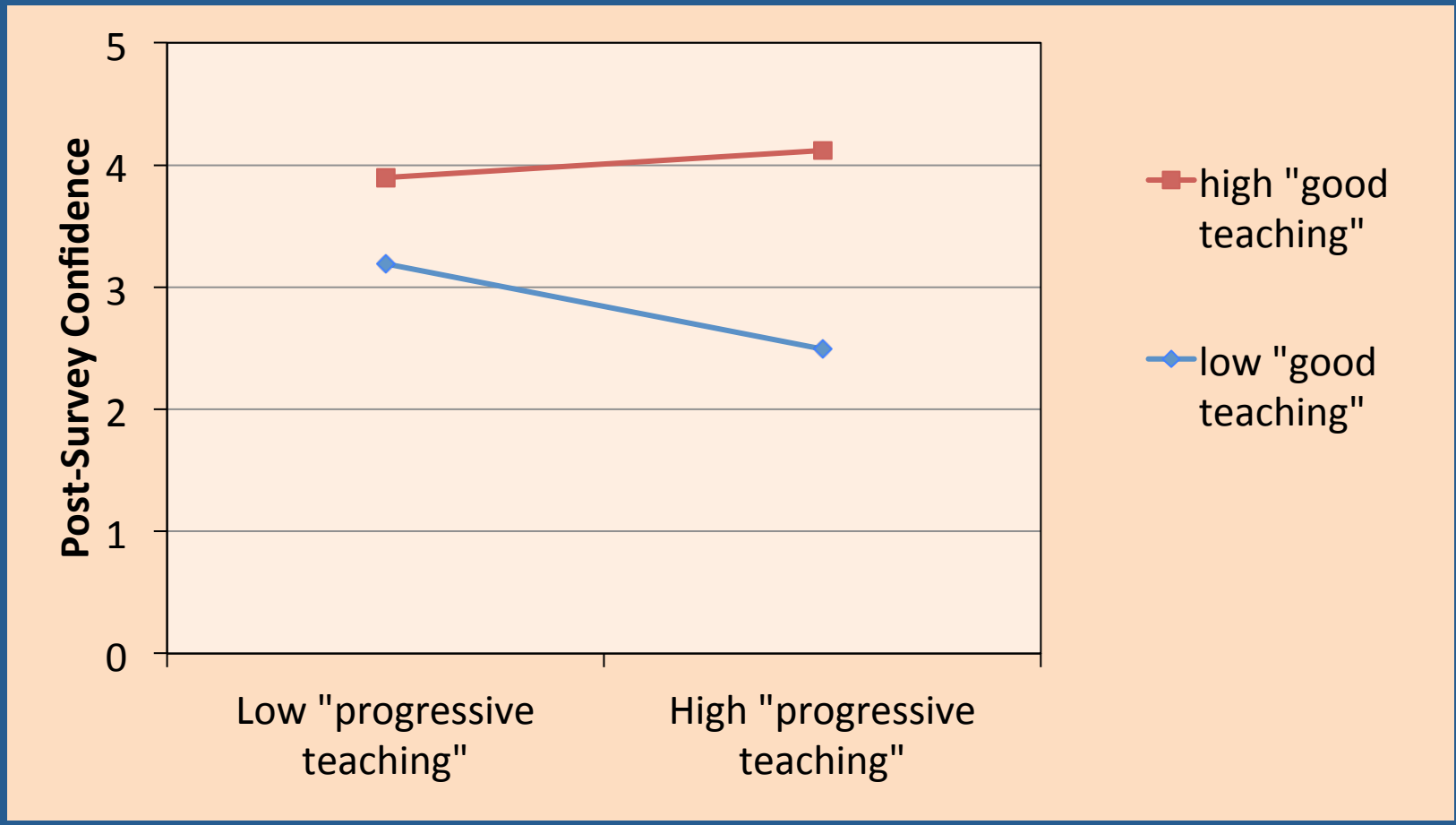
“Progressive Teaching”

My Calculus Instructor:

- Required me to explain my thinking on homework and exams
- Required students to work together
- Had students give presentations
- Held class discussions
- Put word problems in the homework and on the exams
- Put questions on the exams unlike those done in class
- Returned assignments with helpful feedback and comments

Significant interaction with good teaching

Interaction



Switcher Analysis

Chris Rasmussen
Jess Ellis
Kristin Duncan

Students who enter intending a STEM major and continuing to Calculus II:

12.5% have changed their mind about continuing to Calculus II by end of course.

17% of women switched out
9% of men switched out

17.5% of those at large research universities (> 20,000 students) switched out

Analysis of “switchers”, those who originally intended to take Calculus II and pursue STEM major but changed their mind:

No significant differences attributable to

- Ethnic or racial status
- SAT/ACT scores
- Studying calculus in high school
- Amount of time spent working
- Amount of time spent studying

Analysis of “switchers”, those who originally intended to take Calculus II and pursue STEM major but changed their mind:

Switchers are significantly more likely to see success in Calculus as dependent on ability to solve specific types of problems. ($p < 0.001$)

Non-switchers see success as a matter of making connections and forming logical arguments.

Analysis of “switchers”, those who originally intended to take Calculus II and pursue STEM major but changed their mind:

Switchers were far more likely to report that instructor did not engage them during class time.

Switchers were far more likely to report that they did not feel supported or encouraged by their instructor.

Switchers reported that calculus instruction was ineffective and uninspiring, course was “over stuffed” with content, and pace was too fast.

Take away messages:

1. Students who arrive in Calculus I have high levels of interest in mathematics and a desire to understand it.

2. From the start to the end of the course, there is a large and significant decrease in student confidence in their mathematical abilities and enjoyment of mathematics. *This is especially pronounced for women and those who have not studied calculus in high school,*

3. The single greatest factor counteracting this trend that is under the control of the instructor is the quality of teaching *as viewed by the students*.

Take away messages:

4. Students are most likely to continue with mathematics if they find themselves making connections and needing to reason through the concepts.

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