Characteristics of Successful Programs in College Calculus (2009-2015)

Progress through Calculus (2015-2019)

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Characteristics of Successful Programs in College Calculus (CSPCC)

Project Goals

1. To improve our understanding of the demographics of students who enroll in mainstream Calculus I,
2. To measure the impact of the various characteristics of calculus classes that are believed to influence student success,
3. To conduct explanatory case studies of exemplary programs in order to identify why and how these programs succeed,
4. To develop a model that articulates the factors under which students are likely to succeed in calculus, and
5. To use the results of these to leverage improvements in calculus instruction across the United States.

Phase I: Six web-based surveys to identify factors that are correlated with student success in Calculus I

- Stratified random sample of two-year colleges through research universities
- Nearly 14,000 Calculus students from 213 institutions participated
- Data collected included basic demographics and background information, attitudes and beliefs, instructional experience

Phase II: Case studies of 16 successful calculus programs (4 from each type of post secondary institution + pilot sites)

Key Indicators

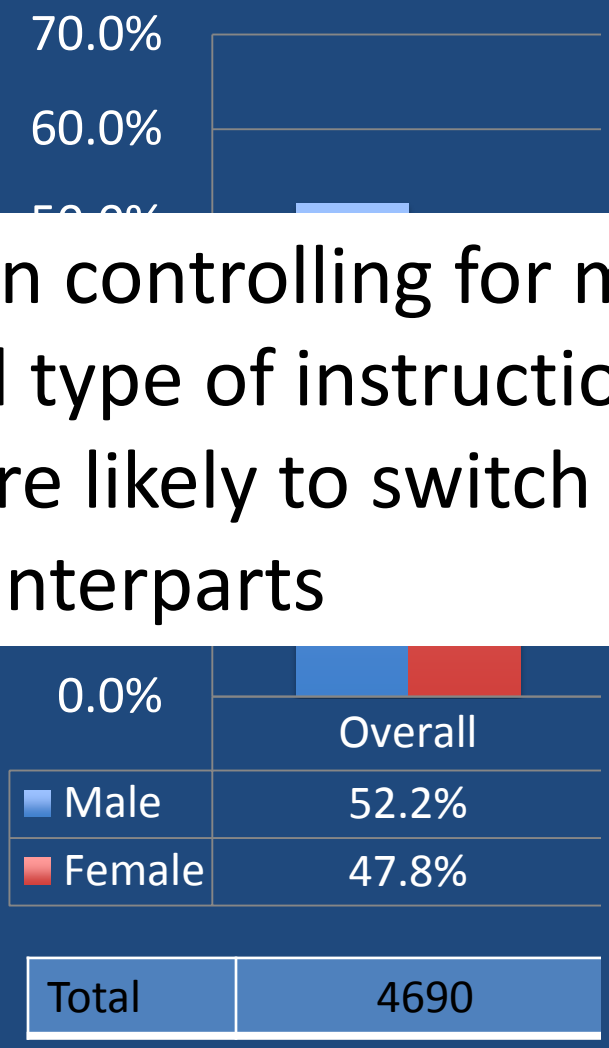
- Persistence in calculus
- Lower DFW rate
- Change in confidence, interest, and enjoyment of mathematics

4 Types of Calc I Students

	Start of term: Intent to take Calc II	End of term: Intent to take Calc II	Number
Culminater	No	No	1789
Persister	Yes	Yes	4710
Switcher	Yes	No	671
Converter	No	Yes	90
			7260

STEM intending

Switchers and Persisters (Rasmussen & Ellis, 2013; Ellis, Fosdick, & Rasmussen, 2016))



Even controlling for major, academic preparation, and type of instruction, females are 1.5 times more likely to switch than their male counterparts

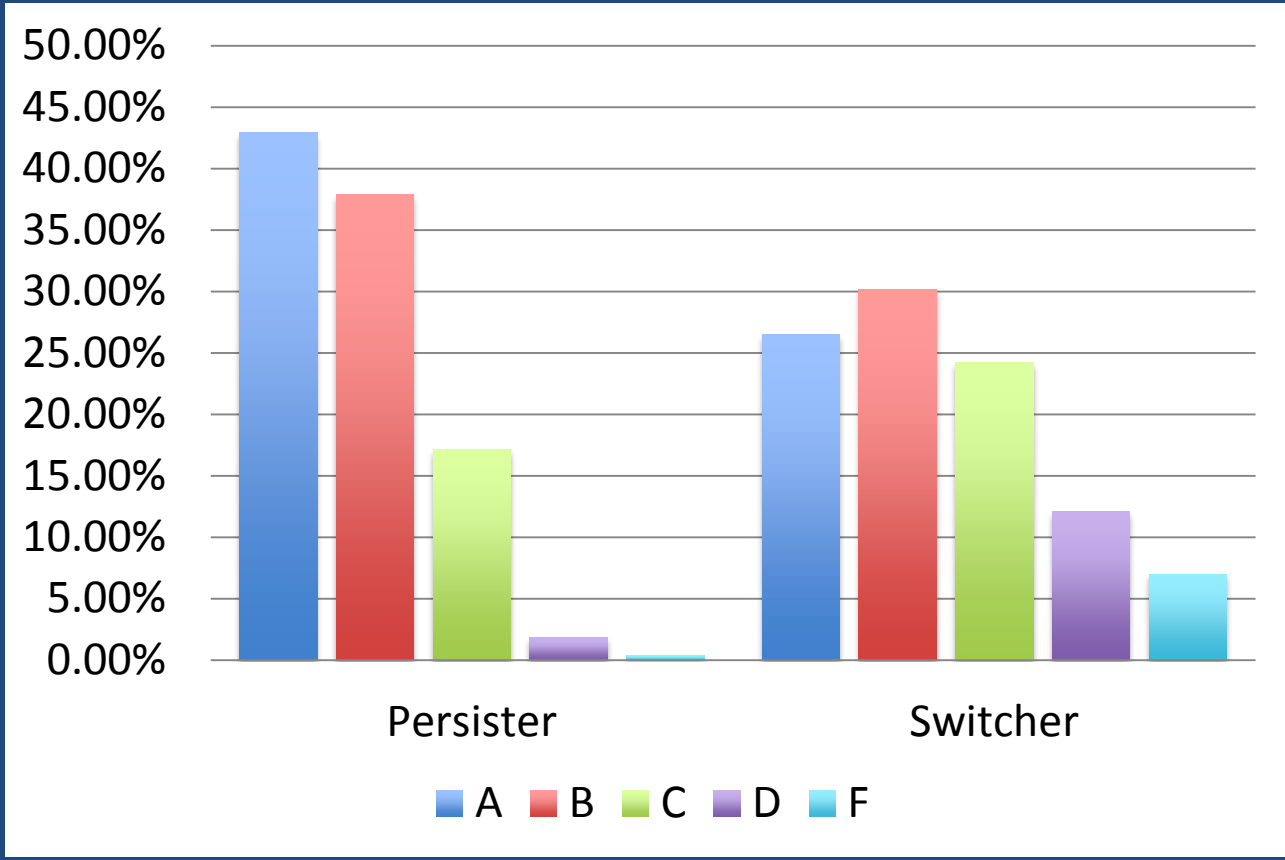
Confidence and Enjoyment

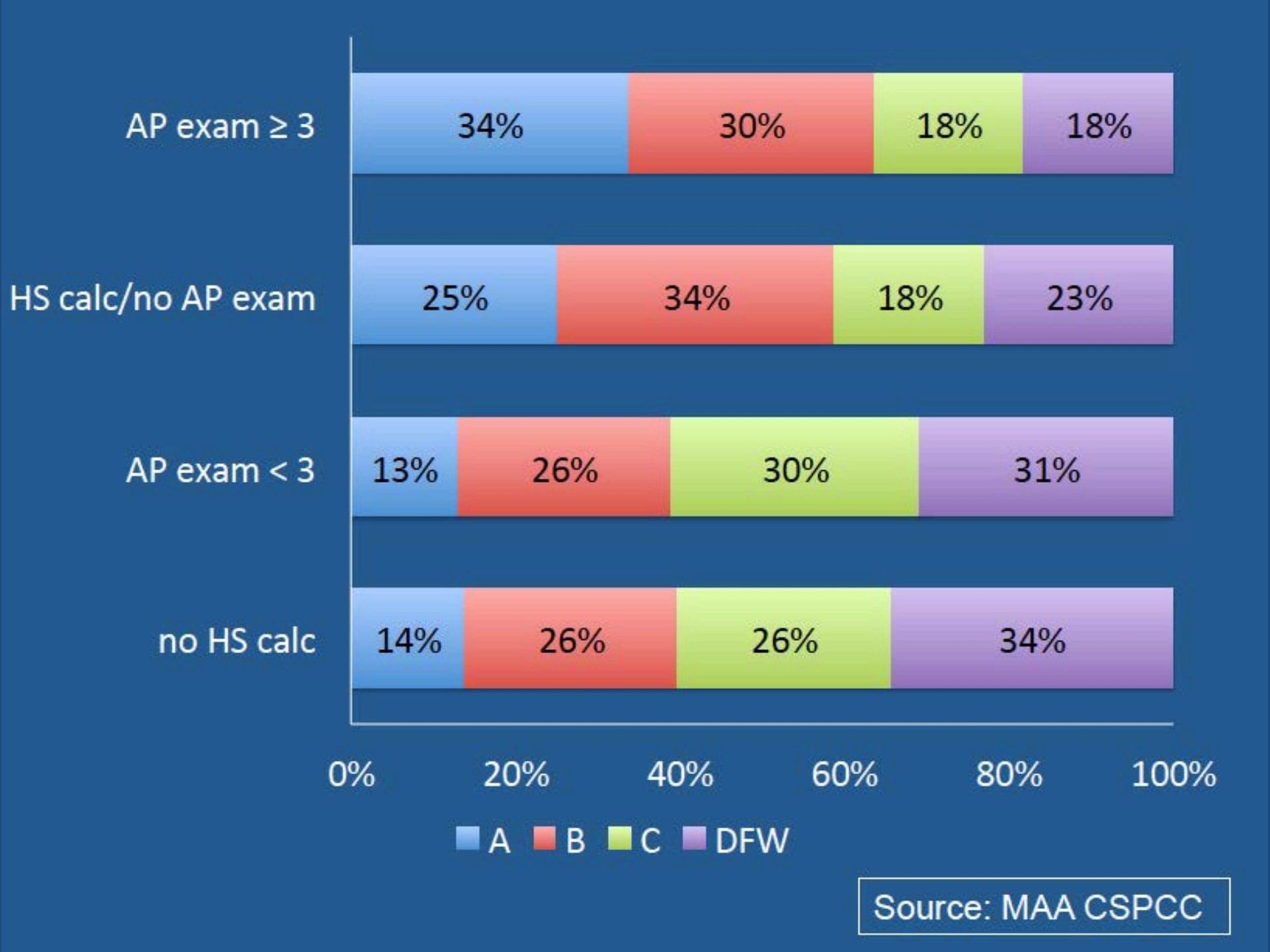
	I am confident in my mathematical abilities		I enjoy doing mathematics	
	Start of term (disagree)	End of Term (disagree)	Start of Term (disagree)	End of Term (disagree)
Persister (2705)	6.9%	15%	13.3%	19.1%
Switcher (477)	8.1%	28.6%	15.1%	28.8%
	$p < .001$	$p < .001$	$p = .011$	$p < .001$

Calculus I is very effective at devastating student confidence and enjoyment of mathematics

Calculus I grade

	C or Better	B or Better
Persister (797)	97.9%	80.8%
Switcher (215)	80.9%	56.7%




AP exam ≥ 3
34%
30%
18%
18%
HS calc/no AP exam
25%
34%
18%
23%
AP exam < 3
13%
26%
30%
31%
no HS calc
14%
26%
26%
34%
0%
20%
40%
60%
80%
100%
A
B
C
DFW
Source: MAA CSPCC

Instructor Pedagogy: Factor analysis
"Good Teaching" and "Ambitious Teaching"

"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 exams were graded fairly
- My calculus exams were a good assessment of what I learned

Instructor Pedagogy: Factor analysis
"Good Teaching" and "Ambitious Teaching"

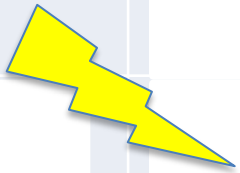
"Ambitious Teaching" (Jackson et al., 2013)

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

Switcher Rates for Low and High Levels of Instructor Quality and Student Centered Practices

	Good Teaching Low	Good Teaching High
Ambitious Teaching Low	16.2%	
Ambitious Teaching High		



Phase 2: Case studies of 5 research universities with successful Calculus I program

Research Question

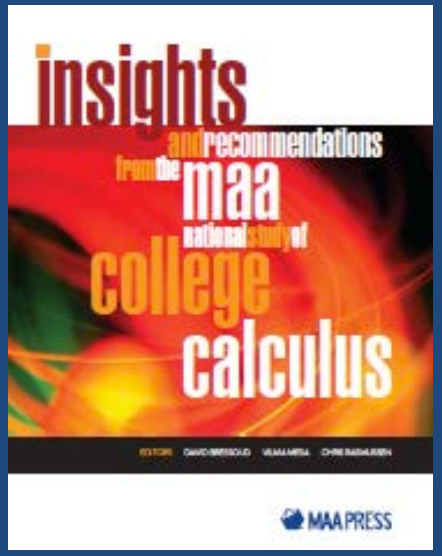
What features, if any, are common among the five successful Calculus I programs at research universities?

Selected Research Universities

School	Enroll-ment	Demographics	Description
Large Public University 1	32,000	14% Hispanic/Latino 2% African American 47% Asian 25% White	• Large number of visiting faculty and post docs who teach calculus • Calculus taught in large lectures with discussion section
Large Public University 2	45,000	4% Hispanic/Latino 5% African American 12% Asian 65% White	• Math PhD students teach almost all sections of Calculus I • Calculus I is taught in small sections with active student engagement
Large Private University	40,000	84% White	• Religious affiliated institution • Strong math public relations program
Private Technical University	6,000	6% Hispanic/Latino 3% African American 6% Asian 69% White	• Three “teaching professors” who run masters programs • Offer a stretched out Calculus I
Public Technical University	8,000	2% Hispanic/Latino 2% African American 81% White	• 97 percent of first-time, full-time students receive financial aid • Offer a Calculus I that meets an extra day

Seven Common Features of Calculus Programs at Research Institutions with Successful Calculus Programs

- Challenging courses
- Attending to local data
- GTA professional development
- Supporting teaching and active learning
- System of Coordination
- Learning resources
- Placement



Returning to Survey Data

GTA professional development activity:	Selected	Non-selected
Faculty observation of GTAs for the purpose of evaluating their teaching	100%	83.9%
Seminar or class for the purpose of GTAs professional development	100%	82.1%
Interview process to select prospective GTAs	50%	34%
Screen GTAs before assigning them to a recitation section	75%	77.4%
Pairs new GTAs with faculty mentors	60%	63%
Other program for GTA mentoring or professional development	75%	50%

Returning to Survey Data

Frequency of instructional activities: *(1=not at all, 6=very often)*	**Selected**	**Non-selected**
ask students to explain their thinking	4.30 (1.42)	3.78 (1.50)
have students work with one another	4.28 (1.84)	2.72 (1.65)
hold a whole-class discussion	3.32 (1.66)	2.68 (1.56)
have students give presentations	2.35 (1.74)	1.46 (0.90)
show students how to work specific problems	5.22 (0.89)	5.13 (1.13)
have students work individually on problems or tasks	3.18 (1.66)	2.82 (1.60)
lecture	5.12 (1.17)	5.26 (1.19)
ask questions	5.08 (1.09)	5.15 (1.09)

Progress through Calculus (PtC) 2015-2019

What are the programs and structures of the Precaclulus through Calculus 2 (P2C2) sequence as currently implemented?

- How common are the various programs and structures? How varied are they in practice? What kinds of changes have recently been undertaken or are currently underway?

What are the effects of structural, curricular, and pedagogical decisions on student success in P2C2?

- Success will be assessed on a variety of measures including longitudinal measures of persistence and retention, performance in subsequent courses, knowledge of both precalculus and calculus topics, and student attitudes.

Progress through Calculus (PtC)

Phase 1: Census survey of all math departments that offer a graduate degree in mathematics

Phase 2: Case studies of 12 departments in the process of improving their program

CSPCC: Models that work

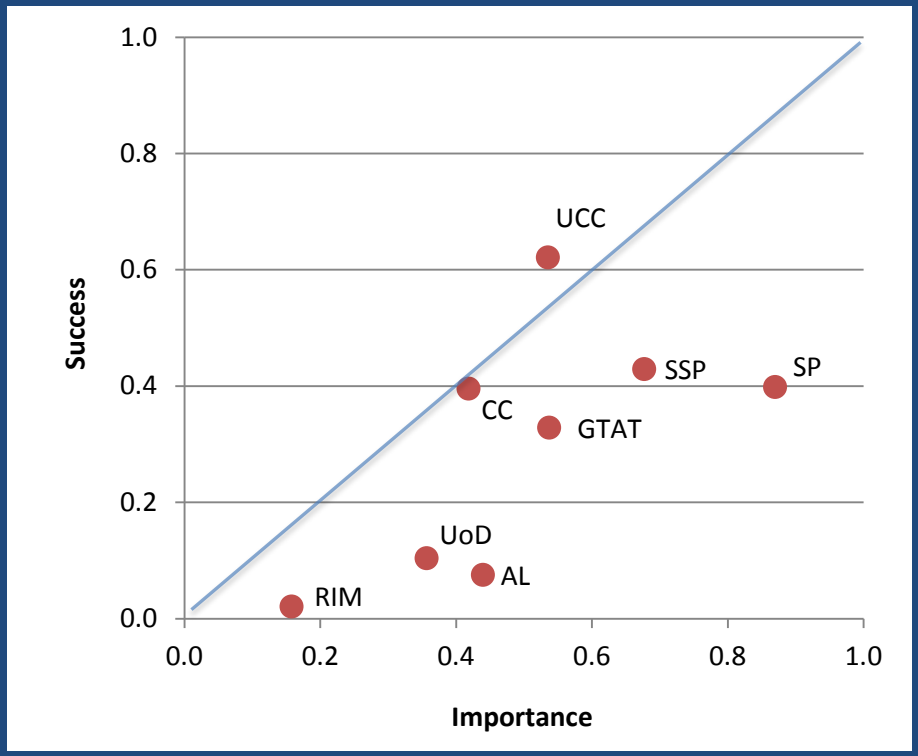
PtC: Models of change that work

Phase 1 Methods and Key Indicators

- Census survey distributed to all 330 institutions that offer a PhD (178) or Masters (152) in mathematics
- Overall response rate: 67.6% (75% PhD, 59% Masters)
- Key Indicators:
  - Seven features of successful programs identified in the CSPCC study
  - Details about P2C2 courses (DFW rate, course format, course innovations, typical instructional practices)

Importance vs. success

- How important are these features for having a successful P2C2 sequence? (Very=1, Somewhat=0, Not=-1)
- How successful is your program with these features? (Very=1, Somewhat=0, Not=-1)



UCC	Uniform course components
CC	Challenging courses
SSP	Student support programs
SP	Student placement
GTAT	GTA training programs
UoD	Use of local data
AL	Active learning
RIM	Regular instructor meanings

Highlights

- 49% of departments considered active learning to be very important, and 41% found use of local data to be similarly important.
- Only 16% consider themselves very successful at implementing active learning, and only 18% rate themselves as very successful at using local data.

Innovative Course Structures

Innovation Type	# of Dept's
Stretched out Calculus	28
Calculus infused with Precalc	9
Co-calculus	2
Calculus for first timers	2
Transition to mainstream	5
Calculus for engineers	14
Calculus for biosciences	14
Accelerated calculus	12

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