

An incentivized early remediation program in Calculus 1:

Lake Ritter* and Jennifer Vandebussche

Kennesaw State University

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Outline

- 1** Background & Motivation
- 2** The remediation program
- 3** Our Study
- 4** Results

Calculus at KSU

- KSU is a large *comprehensive* university serving $\approx 35,000$ on two campuses in suburban Atlanta GA.
- A SAT Math score of 490 (450 prior to March 2016) is required for incoming freshmen.
- Our Calculus sequence is a gateway course for our 13 bachelor programs in Engineering and Engineering Tech. as well as Comp. Sci., and other sciences.
- Placement into Calculus 1 is via successful completion of prerequisite course(s), transfer credit of prerequisite course(s), or recommended based on a **non-proctored** placement exam.
- Calculus 1 is a target course for KSU's *Gateways to Completion* project as well as other initiatives due to its DFW rates.

Pass Rates for Calculus 1 at KSU

Recent Pass Rate Data in Calculus 1

Year	Sections	Students served	ABC	High ¹	Low
2014-15	36	1,686	61.9 %	?	?
2015-16	70	2,631	62.6 %	88 %	30 %
2016-17	77	2,809	57.0 %	95 %	39 %

Enrollment in Calculus 1 exploded post consolidation. Overall pass rates hold primarily steady. However, they can vary widely based on individual instructor.

¹High and Low refer to ABC rates for a single section.

Prerequisite Skills

Even if students can follow the new concepts in calculus, success in the course requires

- the ability to faithfully manipulate algebraic expressions
- understanding function notation, independent-dependent variable relationships
- fluency in the basics or trigonometry
- fluency in the basics of logarithmic and exponential functions²
- familiarity with elementary graphs

²for early transcendental format

Students don't know what they *don't know*

According to the Higher Education Research Institute, students tend to underestimate the workload associated with learning and overestimate their comprehension

Grade Students Predicted versus Grades Received

	A	B	C
Student Predictions N = 269	45 %	43.5 %	8.9 %
Actual Rate N = 293	10.9 %	15.3 %	19.7 %

Our hope is to intervene early to

1. bring any weaknesses to the students' attention, and
2. provide a structured way for students to get on a firm footing.

The remediation program

Our program is modeled after the Calculus 1 *Grade Recovery Program* at West Virginia U. (Hensel, Sigler, & Lowery)³, and the Physics for Engineers *Success Enhancement Program* at U. of Tennessee, Knoxville (Bennett & Schleiter)⁴.

It consists of

- limited in class review of prereq concepts and access to targeted material,
- an early exam over precalculus concepts (week 2 of classes) worth 5.25 % of course grade,
- an optional remediation and exam retake opportunity.

³7. Hensel, R., Sigler, J., Lowery, A. (2008). Breaking The Cycle Of Calculus Failure: Models of Early Math Intervention to Enhance Engineering Retention. Proceedings, ASEE Annual Convention.

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Remediation

Eligibility for retaking the exam is based on completion of tasks.

Remediation Requirements Based on Score

Score (35 max)	Exam Correct	Worksheets	Study Plan	Office Hour
30+ (86 % +)	✓			
25+ (71 % +)	✓	✓		
< 25 (< 71 %)	✓	✓	✓	✓

Office Hours: Originally, the program required students to attend 2 hours of review with the instructor during the 2–2.5 week period between the original testing and the opportunity to retake the test.

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Office Hours: To analyze this component, four sections ran with the requirement and four without during the two semester study.

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Office Hours: We found no statistically significant difference in success rates related to the office hour requirement. Hence we can recommend this be included or not at the discretion of the instructor.

Study

- Two associate professors with experience teaching Calc 1 are running two sections per semester over the course of two semesters (fall '16 and spring '17).
- Each section (for each instructor) is identical **except** that the office hour requirement for retake is included for one section and not for the other.
- We are tracking performance on the prereq exams, embedded final exam questions, and overall course averages.
- Office hour use is being tracked all semester.
- Pre- and Post-surveys are implemented to assess student perceptions.

Some Sample Review Questions

Basic Function Evaluation: Evaluate each expression exactly (answer in radians where appropriate).

(a) $e^{5 \ln 3} =$

(c) $\tan^{-1} 1 =$

(b) $\sin\left(\frac{4\pi}{3}\right) =$

(d) $\cot\left(\frac{2\pi}{3}\right) =$

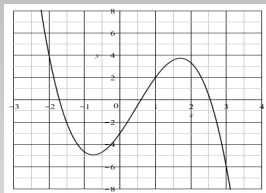
Logarithm Properties: Use appropriate properties of logarithms to completely expand the following into a sum, difference, and constant multiple of logarithms.

$$\ln\left(\frac{x\sqrt{x-1}}{6+x^3}\right)$$

Solving for Linear Variable: Solve the equation for z .

$$2xy^2 + z = xy^3 + 3x^2y^2z.$$

Some Sample Review Questions



$$y = f(x)$$

Referring to the figure, evaluate or answer each of the following questions.

- Evaluate $f(1)$
- Evaluate $f^{-1}(4)$
- How many solutions are there to the equation $f(x) = 0$?
- True or False: f may be a quadratic function.

Some Sample Review Questions

Curve Sketching Sketch the graph of the function f . Provide a plot over (at least) the interval $[-2, 2]$, and label at least two points on the graph.

$$f(x) = \begin{cases} x + 1, & x < 0 \\ e^x, & x \geq 0 \end{cases}$$

Factoring & Root Finding: Find all solutions of the equation:

$$-2(x - 2)^{-3}(x + 1)^4 + 4(x - 2)^{-2}(x + 1)^3 = 0$$

We are happy to make materials available to interested parties. Some materials will likely appear on [figshare.com](https://www.figshare.com).

Results

Data was collected on 293 students.

Summary statistics on pre-test performance.

Attempts	Mean	Median	Std. Dev.
Attempt1	41.7%	40.0%	22.1%
Attempt2	60.9%	62.1%	21.4%
MaxAttempt	49.7%	48.6%	25.3%

Percentages of students scoring at various performance breakpoints.

Score	Attempt1	Attempt2	MaxAttempt
$\geq 70\%$	13.3%	20.5%	28.0%
30-69%	53.2%	22.9%	47.1%
0-29%	33.4%	4.4%	24.9%

Pass rates by students in indicated pre-test score ranges.

Score Range	Attempt1	MaxAttempt
≤ 30%	13.5% (104)	2.6% (78)
31-40%	20.0% (45)	17.5% (40)
41-50%	53.1% (49)	39.5% (38)
51-60%	64.7% (34)	52.8% (36)
61-70%	86.4% (23)	85.0% (20)
71-80%	100% (23)	78.9% (38)
> 80%	100% (15)	88.6% (44)

A *sweet spot* for an 80% pass rate for the course seems to be a score of 57 % on the prerequisite skills exam. Dr. Vandebussche saw this same result the fall following data collection. That is, among students who are able to master just over half the content early in the term, an ABC rate of about 80% is expected.

Some Statistics

Several characteristics were found to have no statistically significant impact on pass rates.

- Instructor (despite different active learning activities)
- Day (2 versus 3 per week), time (early morning versus late morning)
- Term (fall versus spring)
- Office hours use (independent of remediation)

Performing binary logistic regression on the response variable of passing, we found that the only statistically significant factors affecting pass rate were the **pre-test scores** and **participation in remediation**⁵. Higher pre-test scores resulted in a higher pass rate, controlling for participation in remediation. Similarly, participation in remediation resulted in a higher pass rate, controlling for pre-test scores.

⁵Course attendance was not included in the model, since it was too strongly correlated with the grade of *withdraw*.

Attempt1 Scores -vs- Participation in Remediation

Pre-test scores and pass rates for students grouped according to grade breakpoints and remediation participation

Group (N)	Attempt1 Mean	Remediate?	MaxAttempt Mean	Pass Rate %
1 (76)	45.4 %	No	45.4 %	30.2 %
2 (41)	42.3 %	Yes	46.6 %	63.0 %
3 (21)	22.3 %	Yes	46.3 %	40.9 %

Group 1: $30\% \leq \text{Attempt1} \leq 69\%$ + Did Not Remediate

Group 2: $30\% \leq \text{Attempt1} \leq 69\%$ + Did Remediate

Group 3: $\text{Attempt1} < 30\%$ + Did Remediate

Among students who persisted in the course, we find that

Course Avg. = $42.7 + 0.56 \text{ Attempt1} + 5.92 \text{ Retake indicator} - 0.189 \% \text{ missed classes}$.

Concluding Remarks

- Students who choose to participate in remediation can increase their likelihood of passing, even if they only make marginal initial gains.
- The study suggests that there is a population for which this type of program alone is insufficient. However, this program does provide a mechanism for early identification and outreach to such students.
- While we make no claims about *causality*, we hope that sharing results with students can be motivating (and encouraging)!
- This program type is readily adaptable to any math course, or any course that relies heavily on prerequisite skills.

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Thank You!