Identifying “at risk” students in first term calculus

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Abstract

Introductory calculus courses often have a relatively high failure rate, thus acting as “gatekeeper” courses for many disciplines. Students who struggle early in the course and who have low incoming skills are known to be at a higher risk of failure. Some instructors may plan an intervention for such at risk students after a first midterm. Here we demonstrate an alternative approach. Using a multiple regression model built from student data gathered in the first month of classes, at risk students can be identified earlier in the term.

Background

- In North America, first term calculus has a relatively high failure rate (compared with other courses).
- First term calculus acts as a “gatekeeper” course for many disciplines.
- Low incoming skills and low grades early in the course place a student at higher risk of failure.
- Some instructors will identify and reach out to at risk students after a midterm[1].

[1] For an example of intervention, see: Deslauriers, Louis, et al. "Transforming the lowest-performing students: an intervention that worked." Journal of College Science Teaching 41.6 (2012): 76.

Motivation

- Educators want to identify at risk students early in the semester when planning an intervention for such students.
- Researchers want to understand the variables that predict success in calculus.
- Administrators may want to identify at risk students early enough so they can be streamed into another calculus course.

Correlation with grades

Predictor	Timeframe	Correlation with final grade (Pearson's r)	Course
Pre-calculus diagnostic (PCD)	Early September	0.57	Math 100 (N = 967)
Math attitude survey (MAPS)	Early September	0.36	Math 100 (N = 967)
First online homework (HW1)	Middle of September	0.52	Math 100 (N = 967)
First quiz (Q1)	Late September	0.58	Math 100 (N = 967)
Midterm	Mid October	0.81	Math 104 (N=789)

PCD = score on the pre-calculus diagnostic
HW1 = points per attempt for the first online homework
MAPS = Mathematics Attitudes and Perceptions Survey

The Mathematics Attitudes and Perceptions Survey: an instrument to assess expert-like views and dispositions among undergraduate mathematics students , *International Journal of Mathematical Education in Science and Technology*, 2016 Vol. 47, No. 6, 917–937

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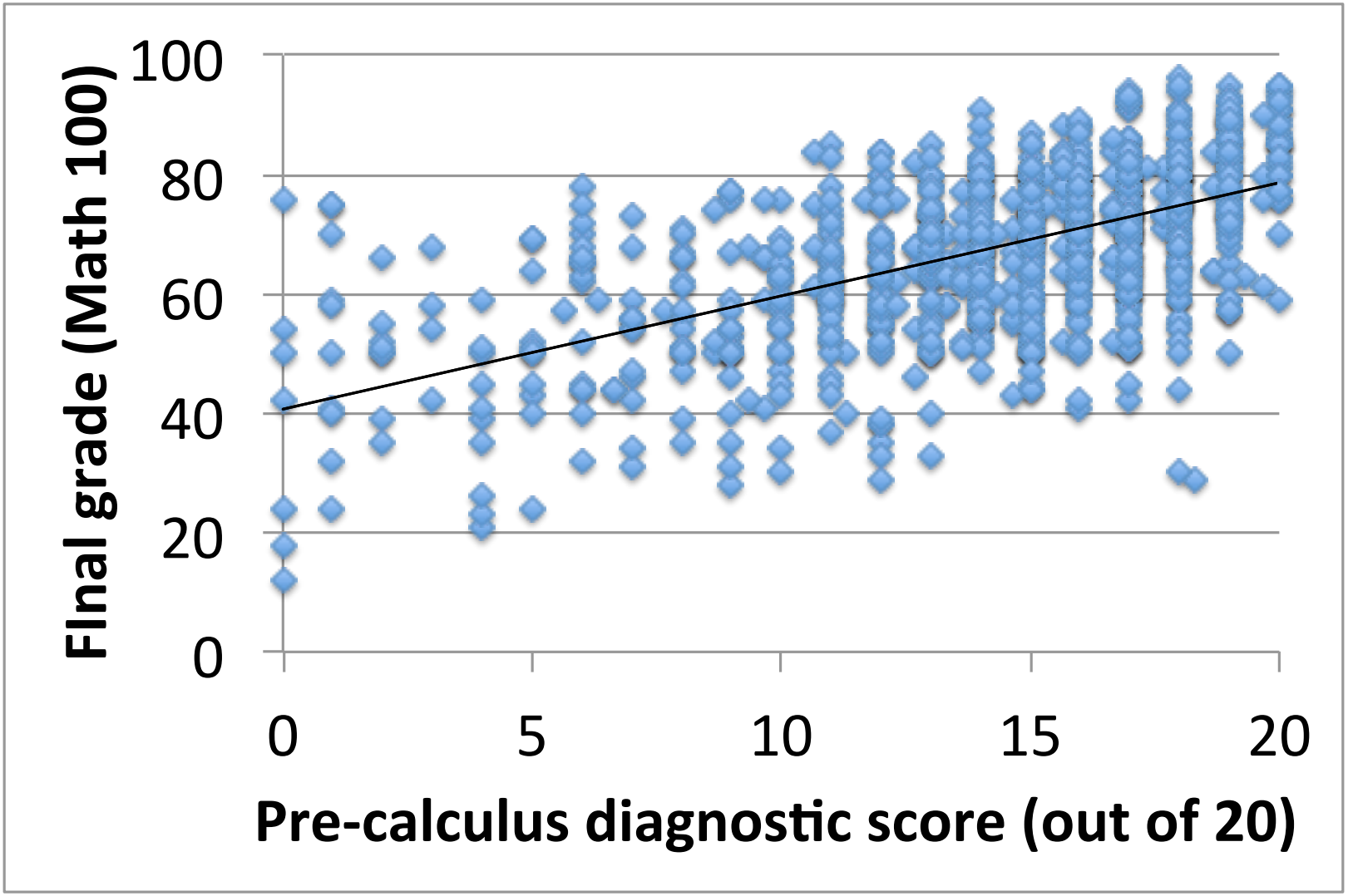
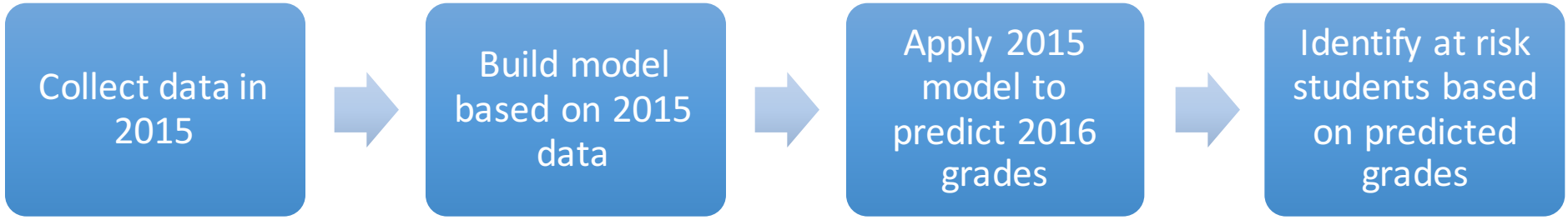


The pre-calculus diagnostic is an online homework with a suggested completion time of one hour, and students receive full credit as long as they attempt it.

Multiple regression modeling



$$Final\ grade = \beta_0 + \beta_1(PCD) + \beta_2(MAPS) + \beta_3(HW1) + \beta_4(Q1) + \varepsilon$$

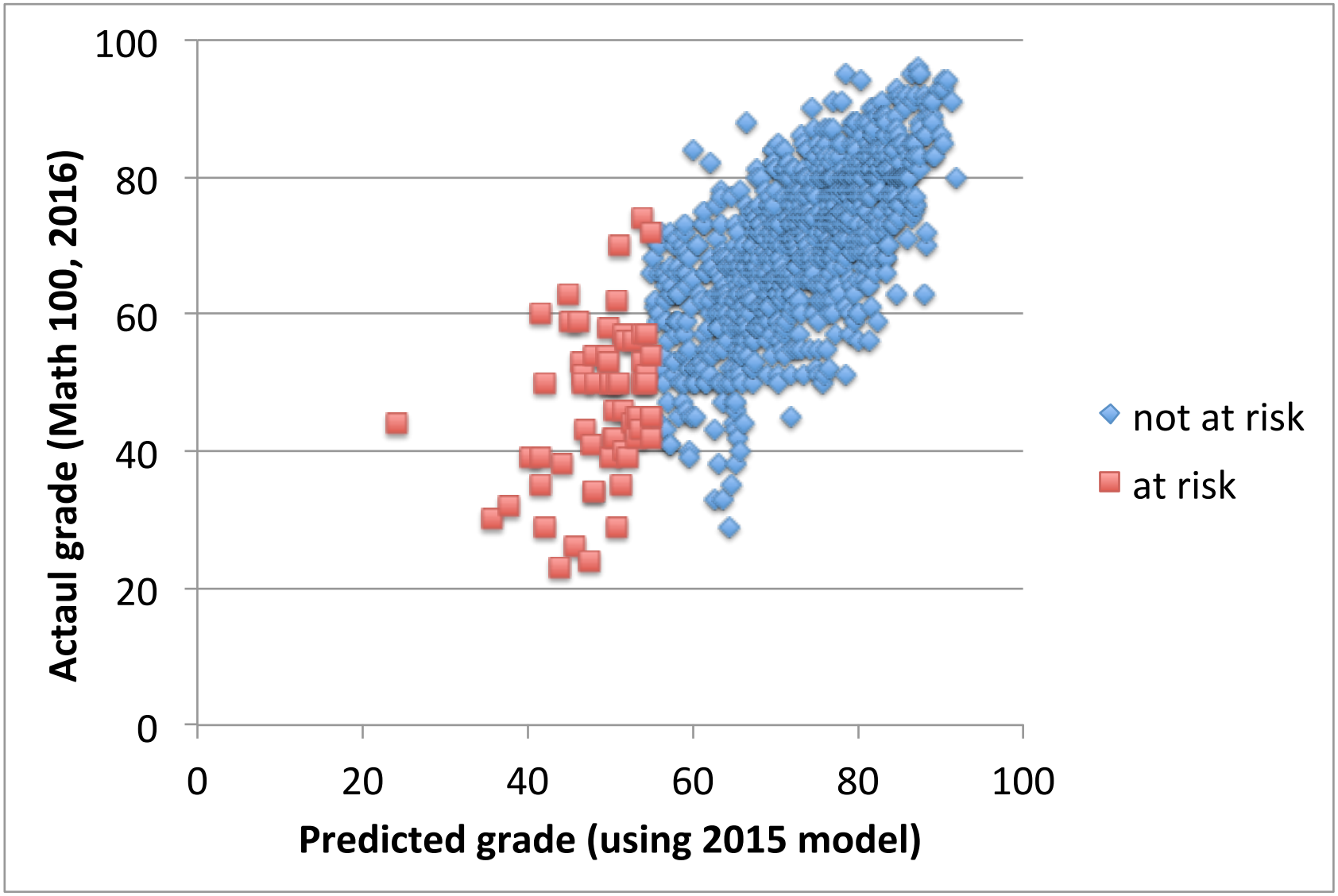
pre-calculus diagnostic

attitude survey

first homework

first quiz

Define a student to be “at risk” if their predicted grade is less than 55%



Accuracy of predictions

- 50% of “at risk” students failed the course

	failed	passed	accuracy
at risk	32	32	50%
not at risk	30	873	97%

Comparing different predictors of pass/fail (Math 100)

Predictors	Timeframe	At risk group size (predicted grade of 55% of less)	Failure rate (in the at risk group)
PCD, MAPS, HW1	Mid Sep	N = 64 (6.9% of class)	38%
First Quiz (Q1)	Late Sep	N = 64	30%
PCD, MAPS, HW1, Q1	Late Sep	N = 64	50%

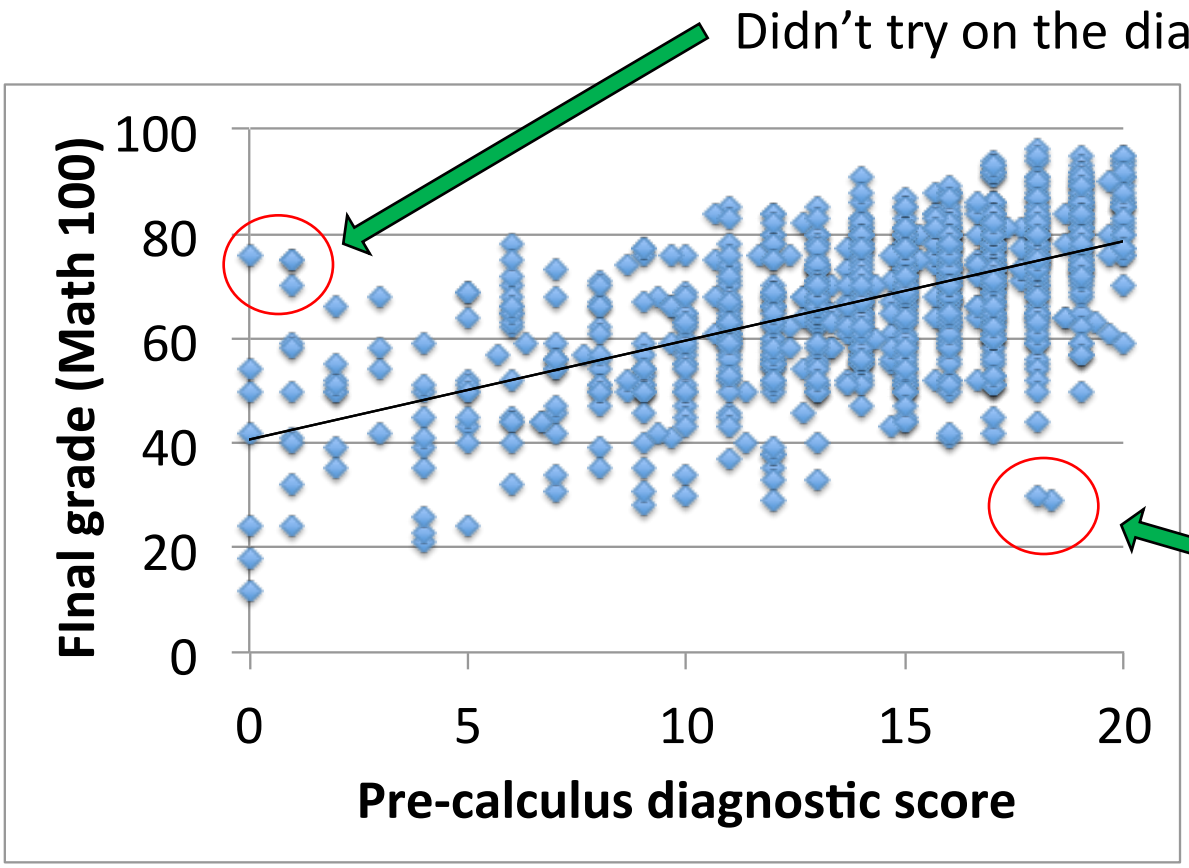
The pre-calculus diagnostic (PCD), attitude survey (MAPS) and first homework (HW1) are at least as good as the first quiz (Q1) in predicting pass/fail.

Comparing different predictors of pass/fail (Math 100 and 104)

Predictors	Timeframe	Course	At risk group (6.7% of the class)	Failure rate (all students)	Failure rate (in the at risk group)
PCD, MAPS and HW1	Mid Sep	Math 104 (2016)	N = 52	6.6%	40%
PCD, MAPS, HW1, Q1	Late Sep	Math 100 (2016)	N = 64	6.4%	50%
Midterm	Mid Oct	Math 104 (2016)	N = 52	6.6%	65%

The midterm is a slightly better predictor of pass/fail in Math 104 than PCD/MAPS/HW1/Q1 in Math 100 (65% accuracy vs 50% accuracy).

Outliers


Didn't try on the diagnostic?
FInal grade (Math 100)
100
80
60
40
20
0
0
5
10
15
20
Pre-calculus diagnostic score
Low grade despite pre-calculus skills

Conclusion

- Student data gathered early in the term can be used to identify at risk students.
- Regression models can be used from one year to the next.
- Current model doesn't incorporate other variables known to predict success, such as study habits.
- Predictive models will always have uncertainty; for example, they don't account for how well a student adjusts to university life.