

Assessing our Calculus Readiness Test

Richard Taylor

Department of Mathematics & Statistics
Thompson Rivers University

Sharing Math, May 2016

Why a readiness test?

- ▶ many students lack basic skills (a.k.a. *algebra*)
- ▶ no system to enforce high school prerequisites
- ▶ no provincial final exams
- ▶ lots of international students

Goal: identify students at risk of failure **due to lack of skills**

Provisos

Students fail calculus for lots of reasons:

- ▶ essential skills
- ▶ effort / motivation
- ▶ language barriers
- ▶ external pressures: job, family, mental health, ...

We can't predict every failure ...

Can we measure a level of knowledge / skills below which success is unlikely?

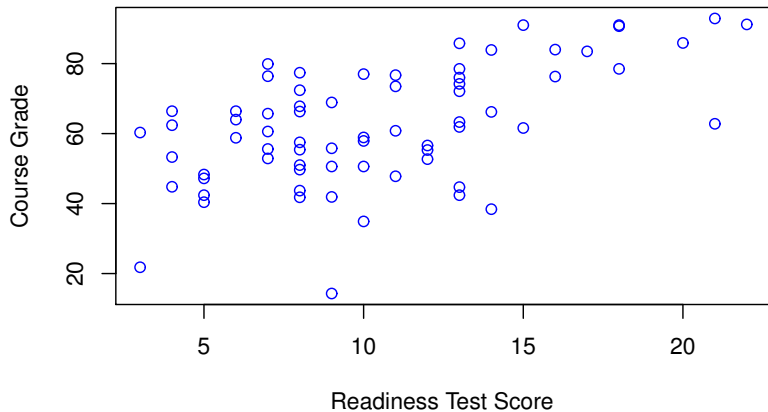
Pilot readiness test: Fall 2014

- ▶ 25 questions
(plagiarized from AMS, MIT, U. Cape Breton,...)
- ▶ 45 minutes
- ▶ given first day of classes (**hmmm...**)
- ▶ tracked outcomes for ~ 100 students

Is readiness test score correlated with course grade?

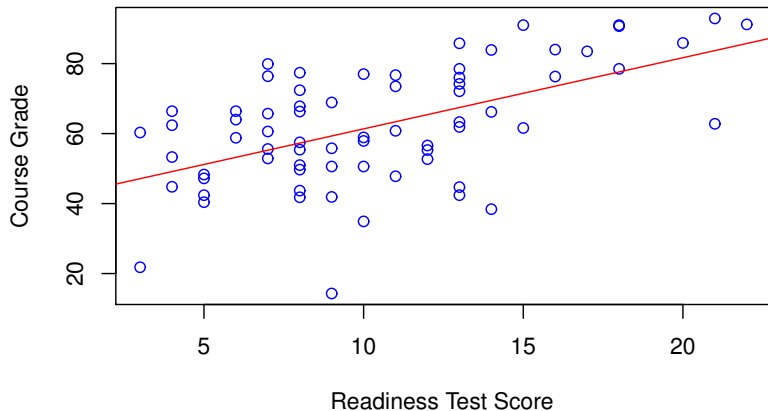
Pilot Results (Fall 2014)

Course Grade vs. Test Score (Original Test)

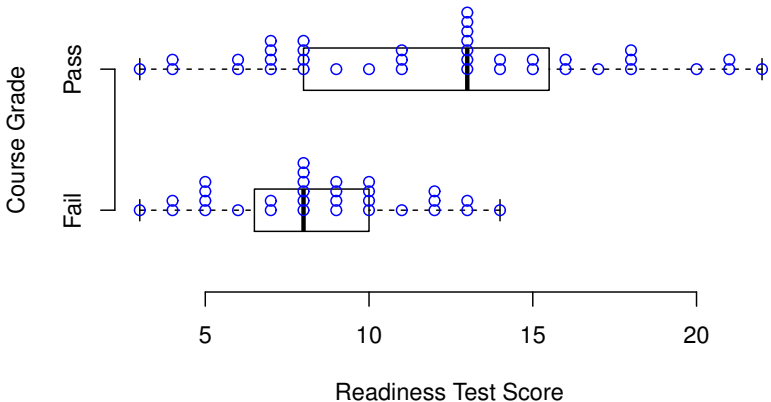


Pilot Results (Fall 2014)

Course Grade vs. Test Score (Original Test)

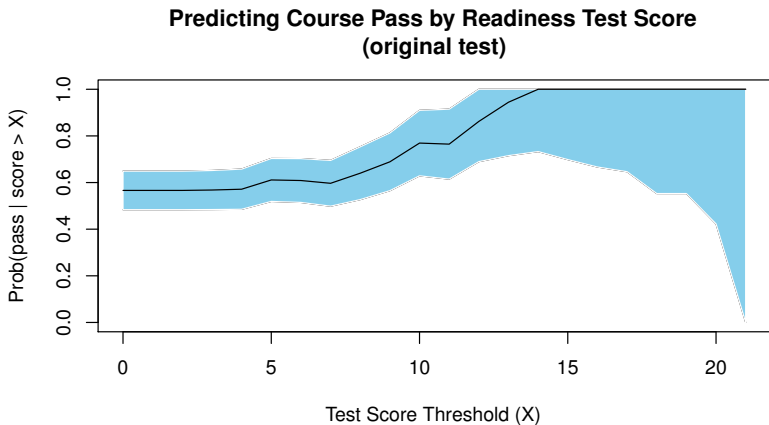


Test Scores by Course Outcome (Original Test)

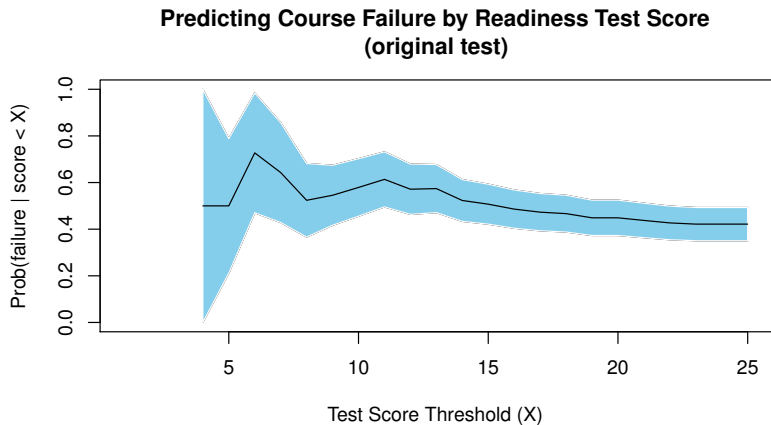


“Pass” = “course grade > 60%”

We can predict a pass. . .



but not failures...

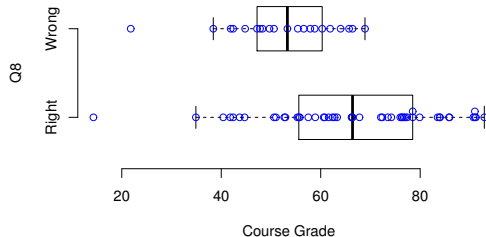


Summary

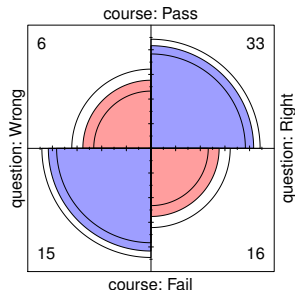
- ▶ failing students typically did worse on the readiness test
- ▶ but lots of outliers:
 - ▶ students with very low test scores who did well
 - ▶ students with good test scores who still failed
- ▶ $\text{score} > 12 \implies$ very likely to pass
- ▶ but \nexists score below which failure probability is much higher than 44% “background rate”

**Most of the questions are poor discriminators.
How to improve on this?**

A Good Question:



Contingency Table for Q8



Q8 is predictive: **wrong answer** \implies **likely to fail**

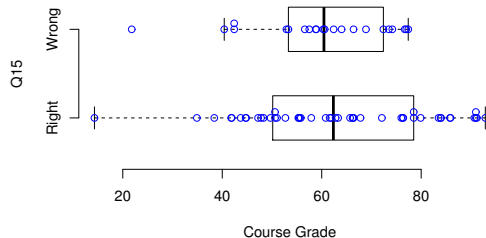
$$\text{odds ratio} = \frac{\text{odds of failure if answering wrong}}{\text{odds of failure if answering right}} = \frac{15/6}{16/33} \approx 5.2$$

A Good Question:

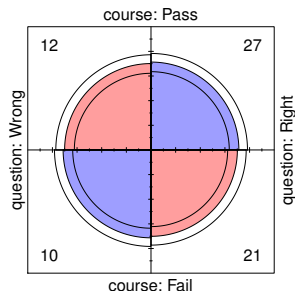
If $f(x) = \frac{3x+4}{x+3}$ then $f(a+2) =$

- (a) 2 (b) $\frac{3a+7}{a+5}$ (c) $\frac{3a+6}{a+5}$ (d) $\frac{3a+4}{a+3}$ (e) $\frac{3a+10}{a+5}$

An Irrelevant Question:



Contingency Table for Q15



Q15 is not predictive:

$$\text{odds ratio} = \frac{10/12}{21/27} \approx 1.07$$

Answers appear random. Q15 just adds noise to the test scores!

An Irrelevant Question:

Simplify: $\frac{\sqrt{a^8b^4}}{a^2b}$

(a) a^6b^3

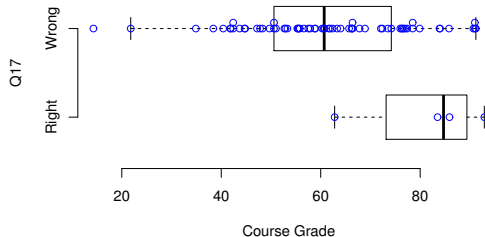
(b) a^4b^2

(c) a^2b

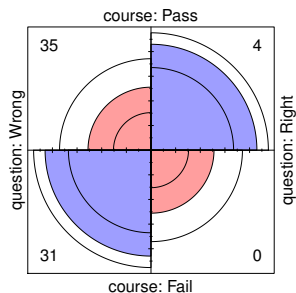
(d) a^2

(e) b^2

A Too-Difficult Question:



Contingency Table for Q17

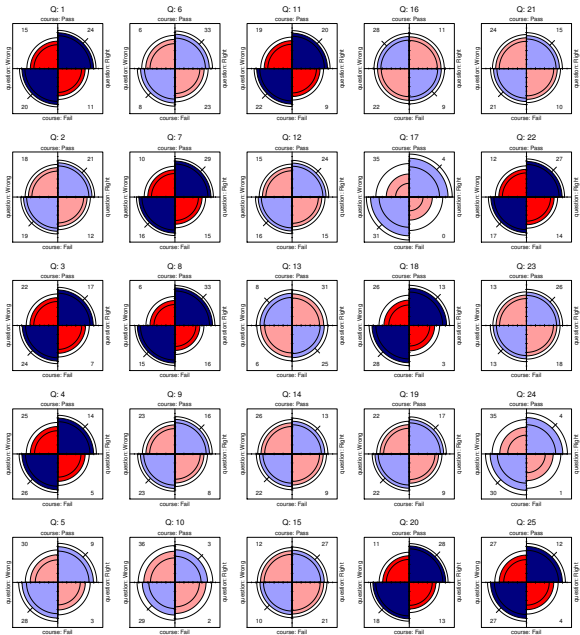


Q17 is too difficult:

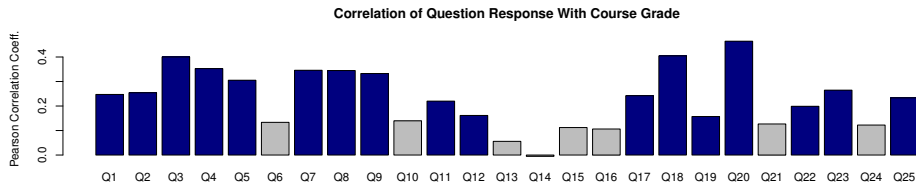
- ▶ too few right answers
- ▶ positive odds ratio not statistically significant
- ▶ yields no information on most students

A Too-Difficult Question:

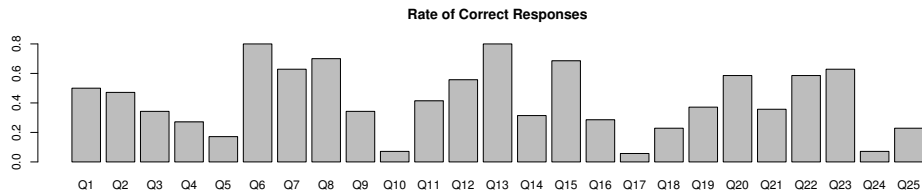
Solve for x :
$$\frac{9}{x-10} - \frac{204}{x^2-100} = 1$$



Correlations with course grade



Lots of hard questions



Conclusions (2014/15)

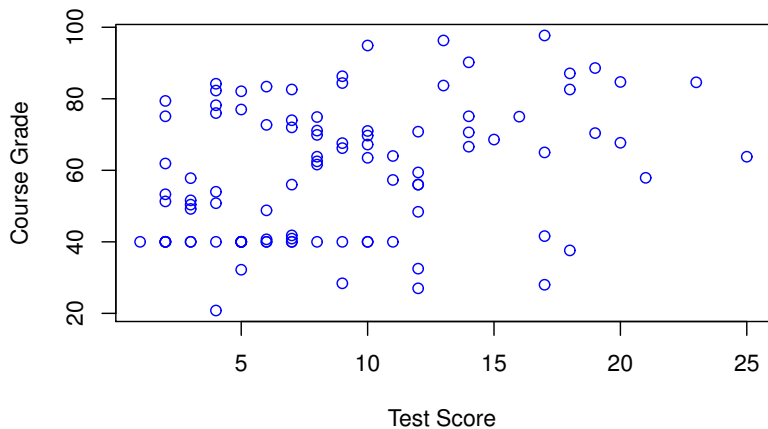
- ▶ 2015 test has little predictive value
- ▶ too many bad questions:
 - ▶ poor discriminators
 - ▶ too difficult (so uninformative)
- ▶ only 10 (of 25) questions have good predictive value
- ▶ 10 good questions not enough: need at least 20 for test score to discriminate “passing” and “failing” populations

Revised Test for 2015/16:

- ▶ delete poor discriminators
- ▶ make too-hard questions easier
- ▶ add new questions to give 25 total

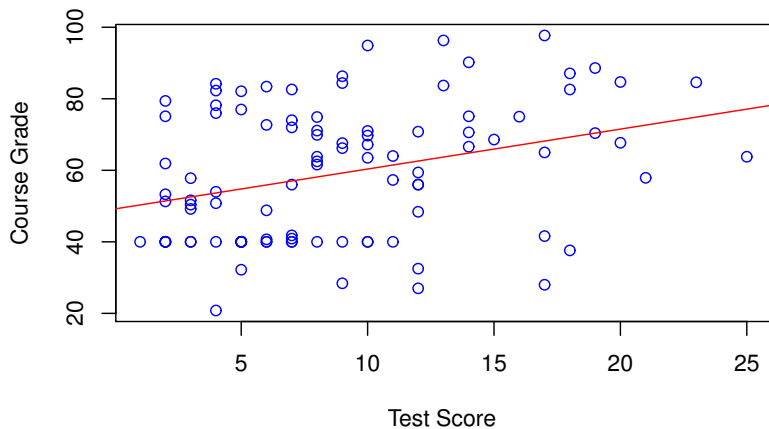
Results (Fall 2015)

Course Grade vs. Test Score



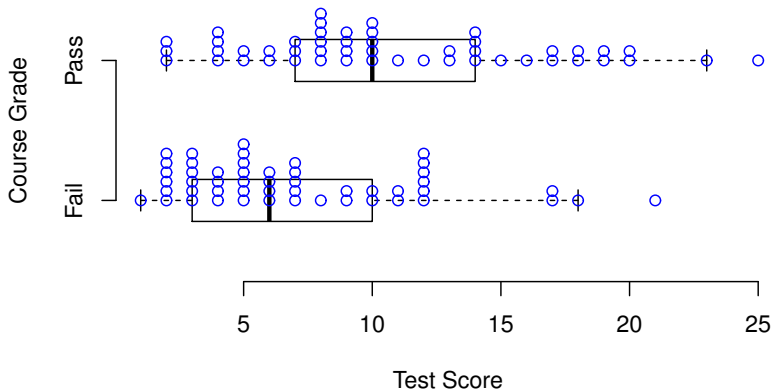
Results (Fall 2015)

Course Grade vs. Test Score



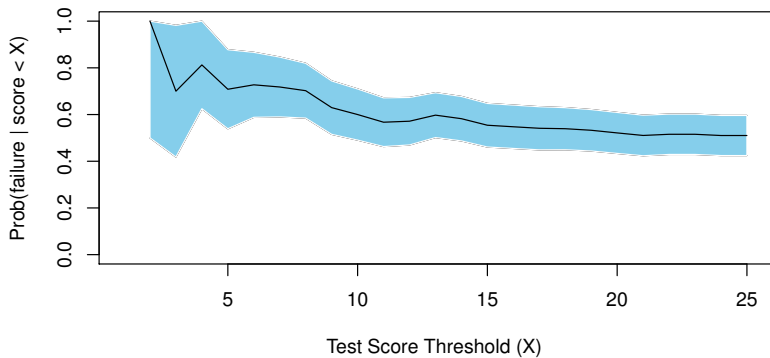
Results (Fall 2015)

Test Scores by Course Outcome

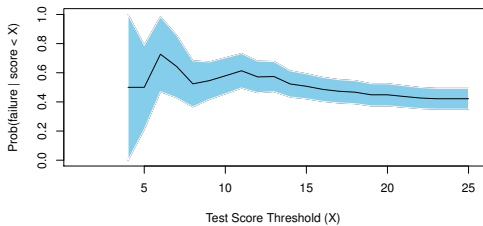


Low score \Rightarrow high risk of failure

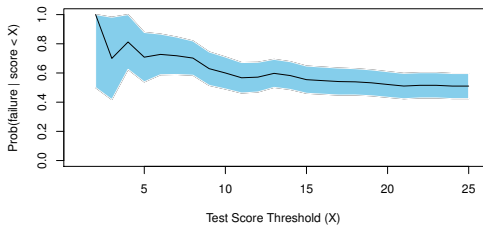
Predicting "Fail" by Score Below Threshold (2016)



**Predicting Course Failure by Readiness Test Score
(original test)**

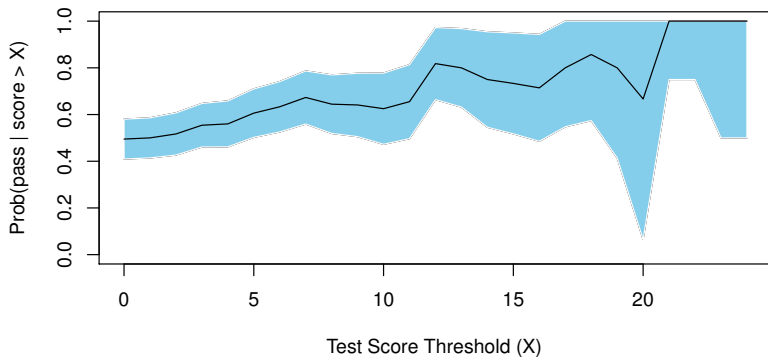


Predicting "Fail" by Score Below Threshold (2016)

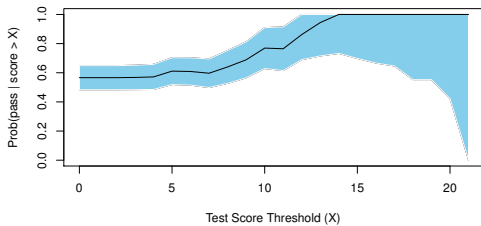


High score \implies high chance of success

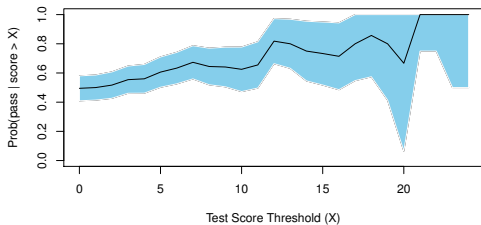
Predicting "Pass" by Score Above Threshold (2016)

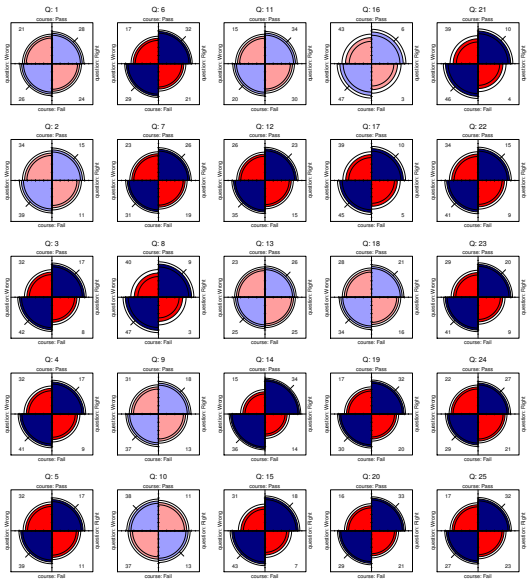


**Predicting Course Pass by Readiness Test Score
(original test)**

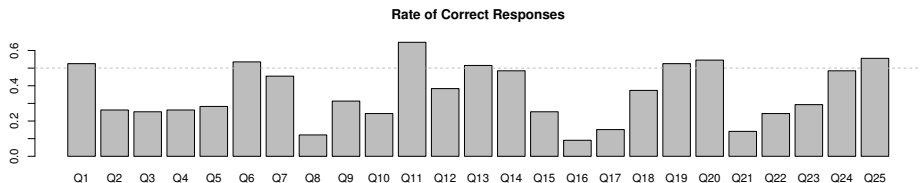
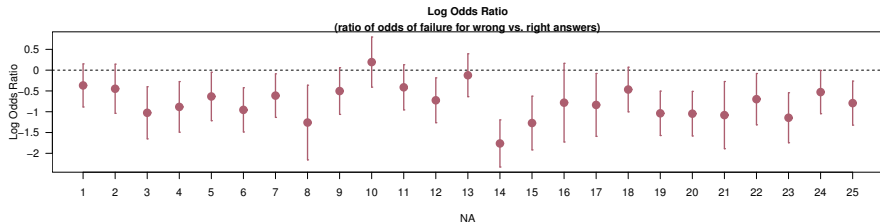


Predicting "Pass" by Score Above Threshold (2016)





Quality of questions (Fall 2015)



Conclusions

Revised test is a useful advising tool:

- ▶ score below 8/25 \implies high risk (65%) of failure
- ▶ score above 12/25 \implies good chance (65%) of success

Need one more iteration:

- ▶ have 17 good(ish) questions... need more
- ▶ many questions still too hard