Measuring and predicting the mathematical preparedness of introductory physics students

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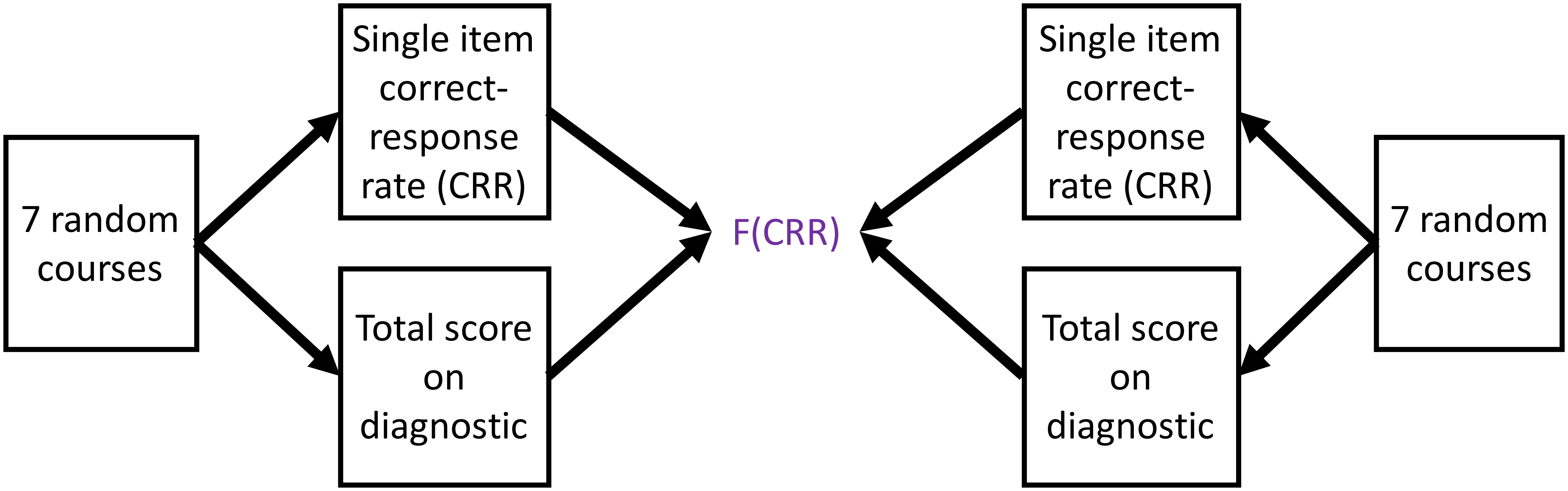
Predicting mathematical preparedness

- Our diagnostic was administered to over 1,900 students at three large university campuses over the course of three semesters

- From these data, we have found interesting relationships between diagnostic items and overall diagnostic performance

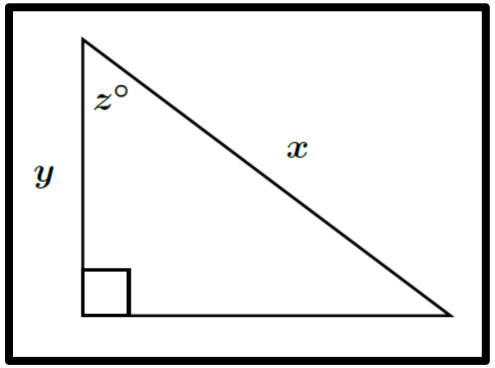
  - Performance at the course, and individual student level

Predicting *course* correct response rate on entire diagnostic



Good predictor items

Item 1



Item 7

Solve for x.

$$ax + b = cx + d$$

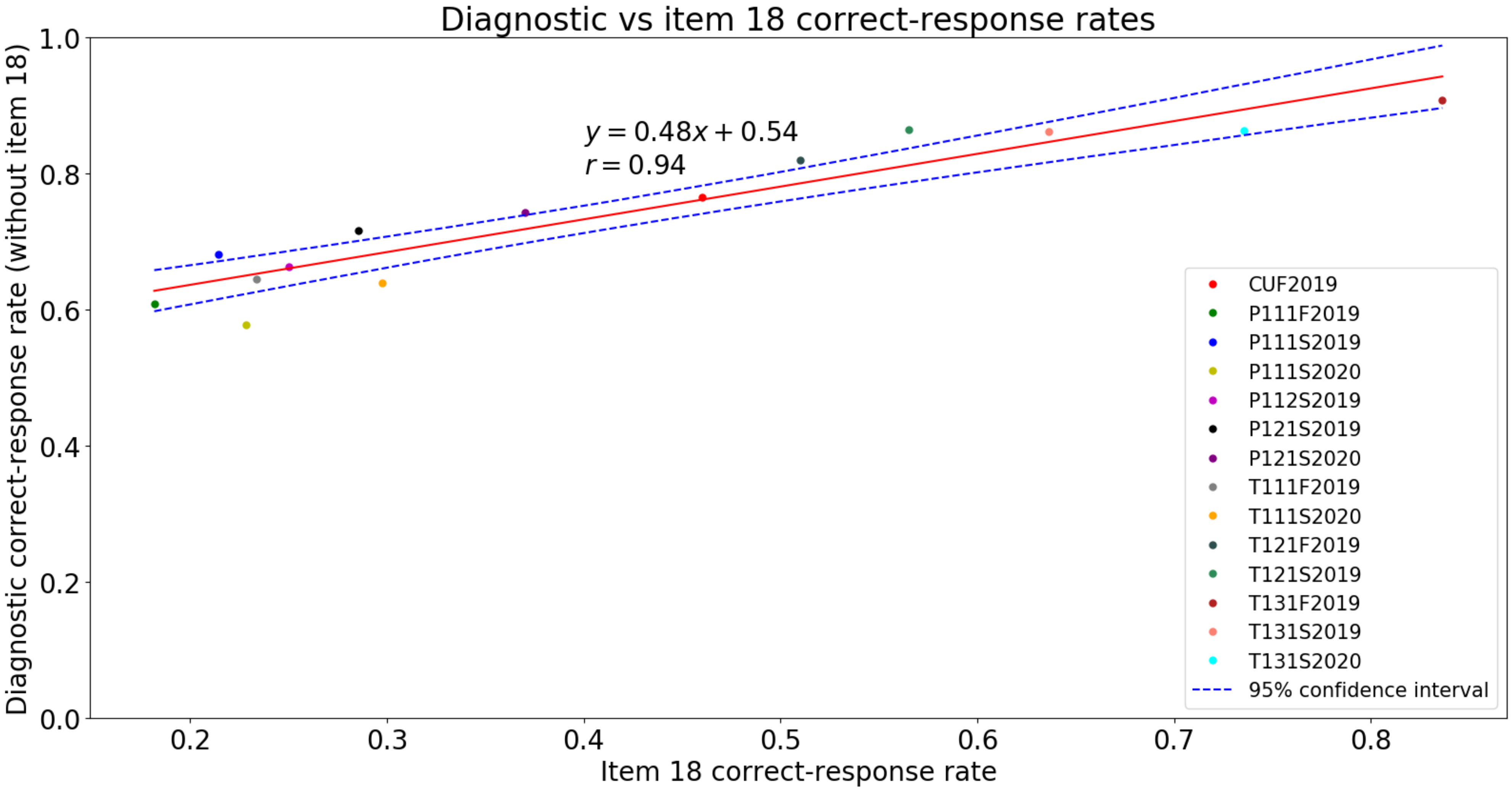
Item 18

$$cy = dx$$

$$a - y = bx$$

$$x = ?$$

Item 18 as a predictor



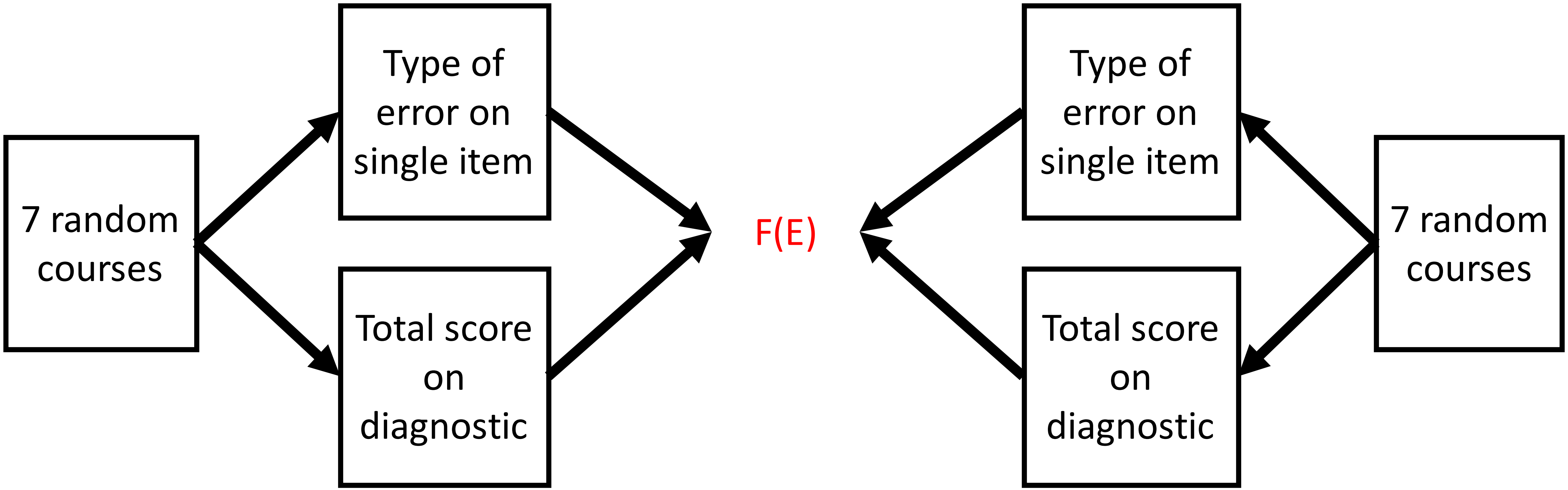
$$cy = dx$$

$$a - y = bx$$

$$x = ?$$

- R-squared: 0.88

Predicting course correct response rate on entire diagnostic (method 2)



Method 2: items involved

Item 9

$$2\left(\frac{a}{b}\right) = ?$$

Item 8

$$\left(\frac{a}{3}\right)^3 = ?$$

Item 11

$$\frac{a/b}{c^2/d} = ?$$

Item 14

$$v^2 = v_0^2 + 2ad$$

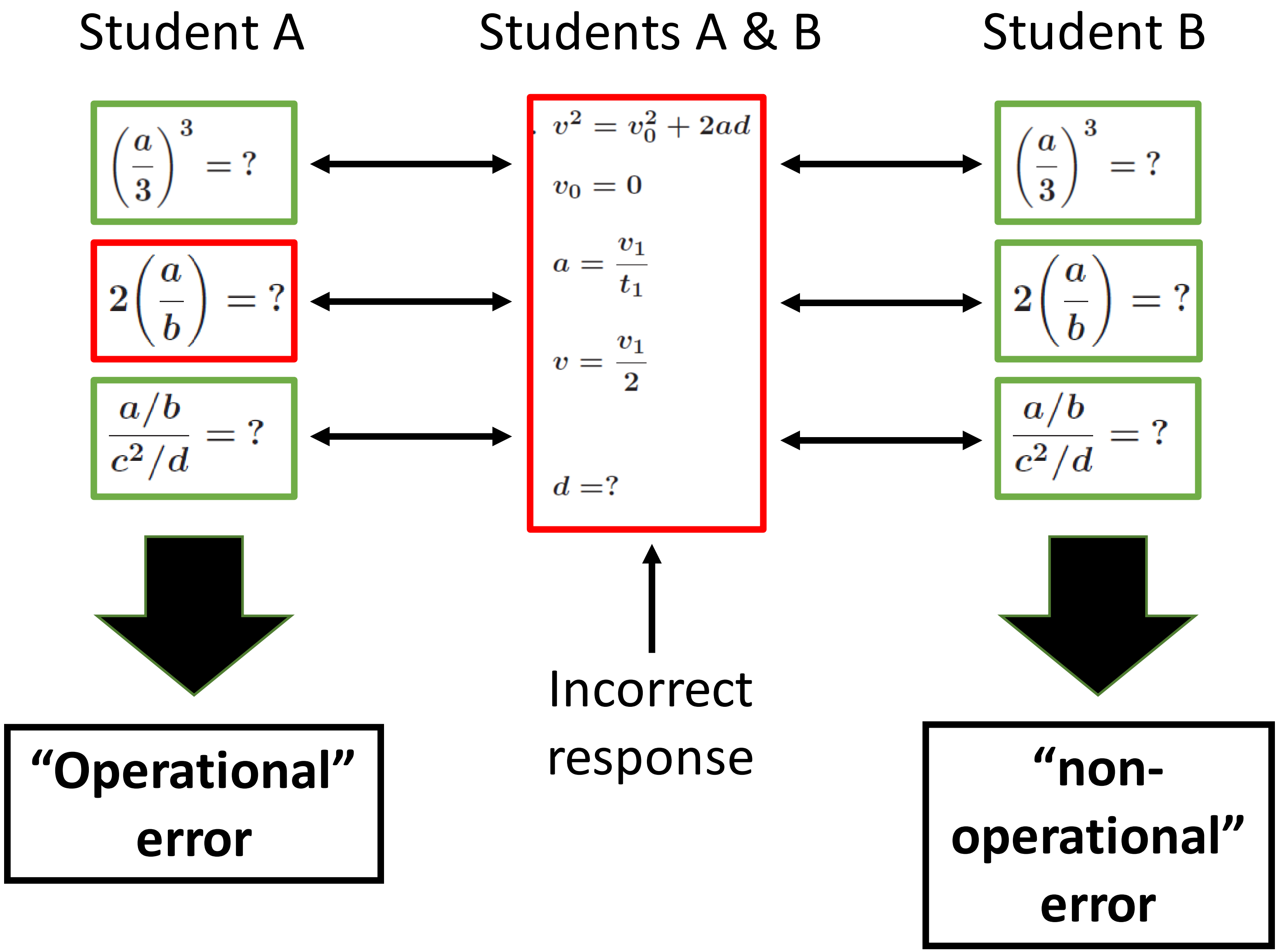
$$v_0 = 0$$

$$a = \frac{v_1}{t_1}$$

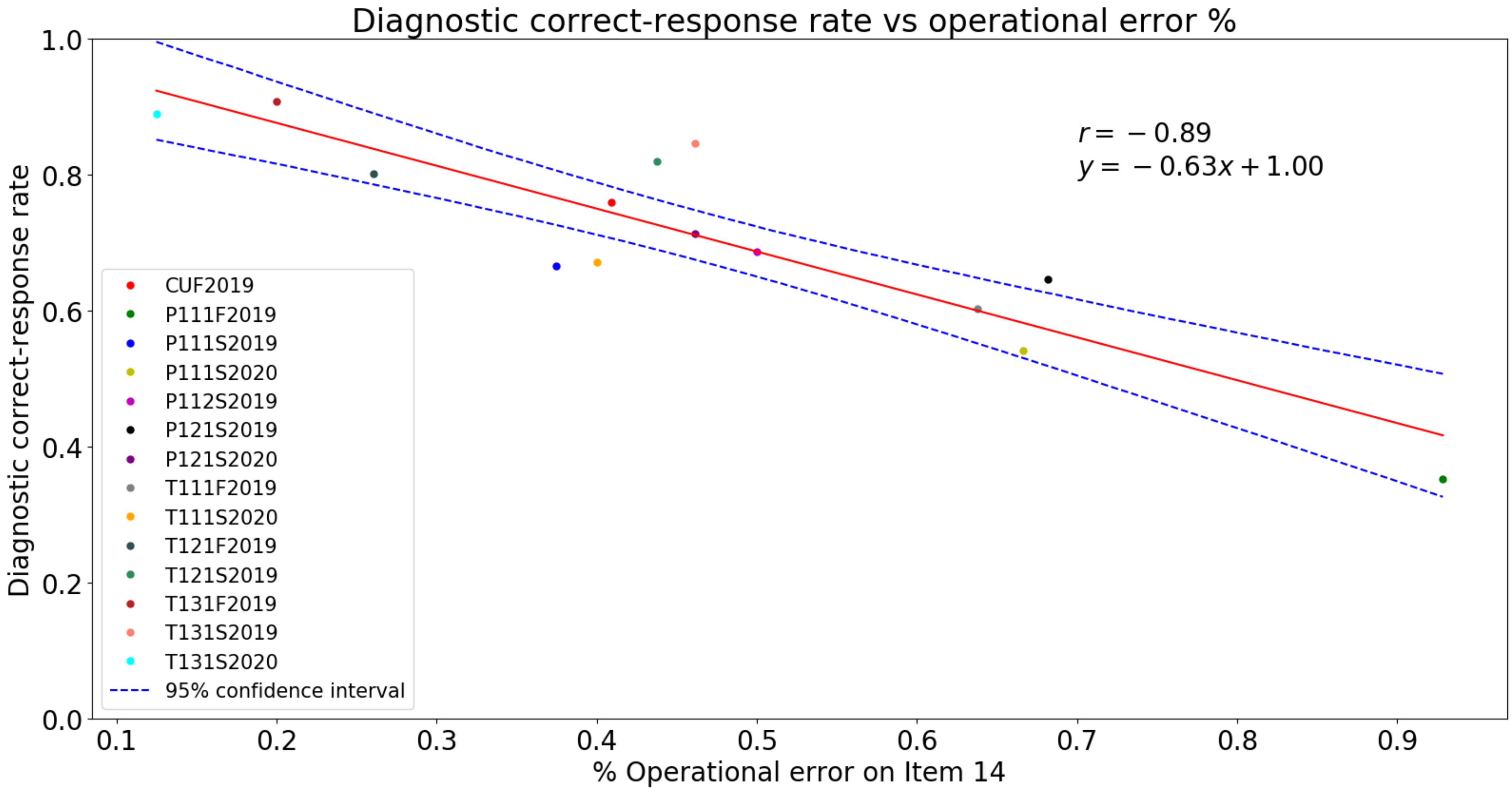
$$v = \frac{v_1}{2}$$

$$d = ?$$

Error "type"


Student A
Students A & B
Student B
$\left(\frac{a}{3}\right)^3 = ?$
$2\left(\frac{a}{b}\right) = ?$
$\frac{a/b}{c^2/d} = ?$
$v^2 = v_0^2 + 2ad$
$v_0 = 0$
$a = \frac{v_1}{t_1}$
$v = \frac{v_1}{2}$
$d = ?$
$\left(\frac{a}{3}\right)^3 = ?$
$2\left(\frac{a}{b}\right) = ?$
$\frac{a/b}{c^2/d} = ?$
"Operational" error
Incorrect response
"non-operational" error

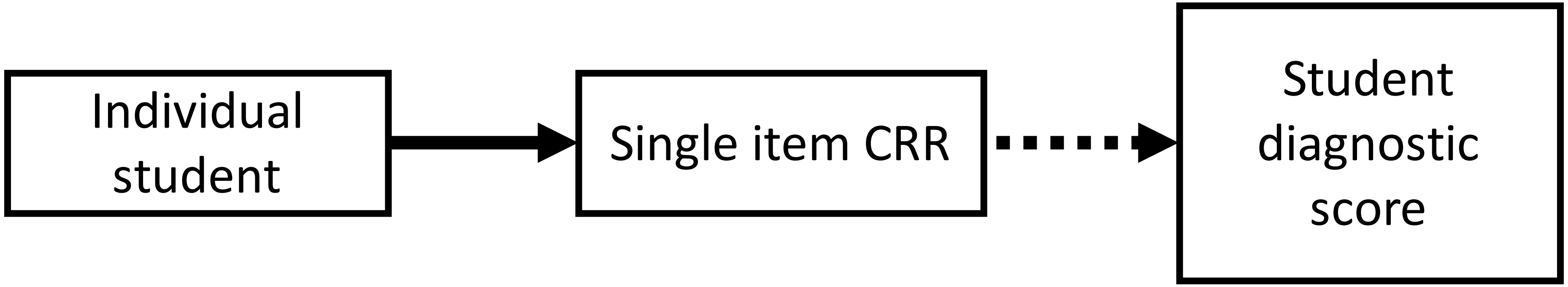
% Operational error as a predictor



Predicting course performance summary

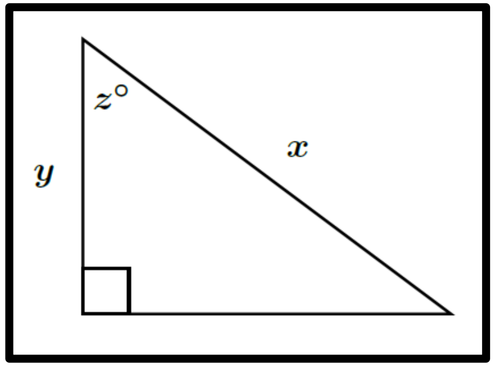
- We find that course correct-response rates on the entire diagnostic are highly predictable
  - We can predict diagnostic correct-response rate by simply examining the course correct-response rate on a single item
  - The best predictor items are generally "symbolic" type problems
- Recall, this is true for courses varying in academic term, course level, university, and campus

Individual student correlations



Student correlations on the same items

Item 1



Item 7

Solve for x.

$$ax + b = cx + d$$

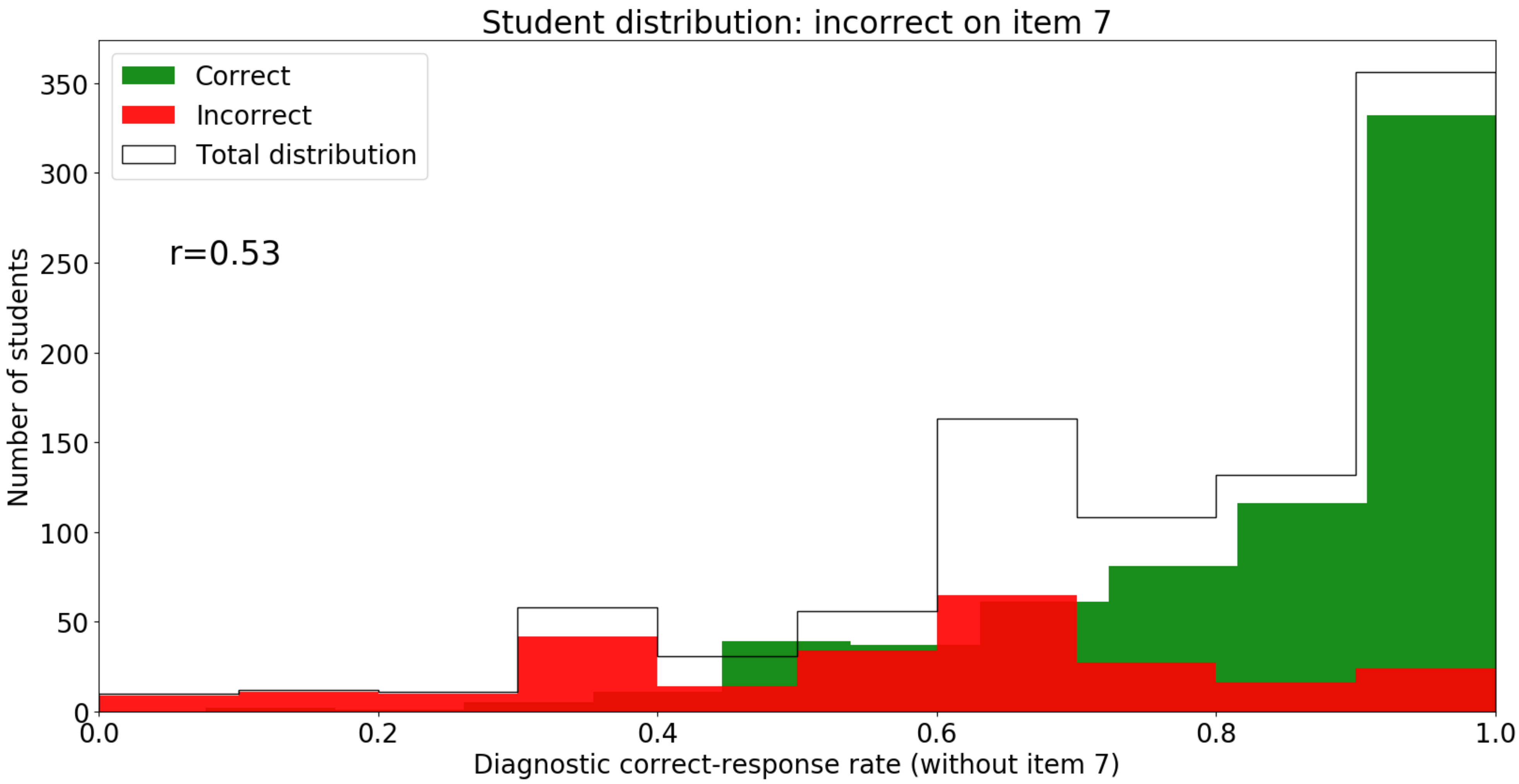
Item 18

$$cy = dx$$

$$a - y = bx$$

$$x = ?$$

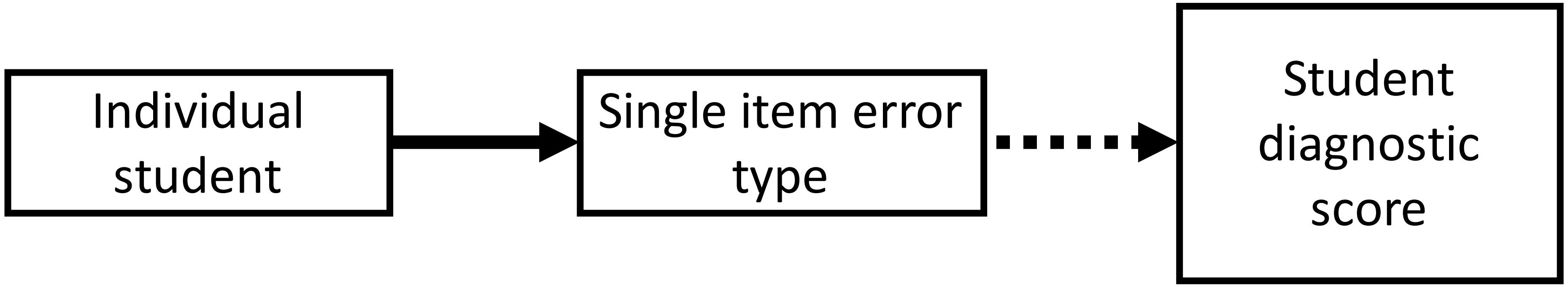
Student distribution on item 7

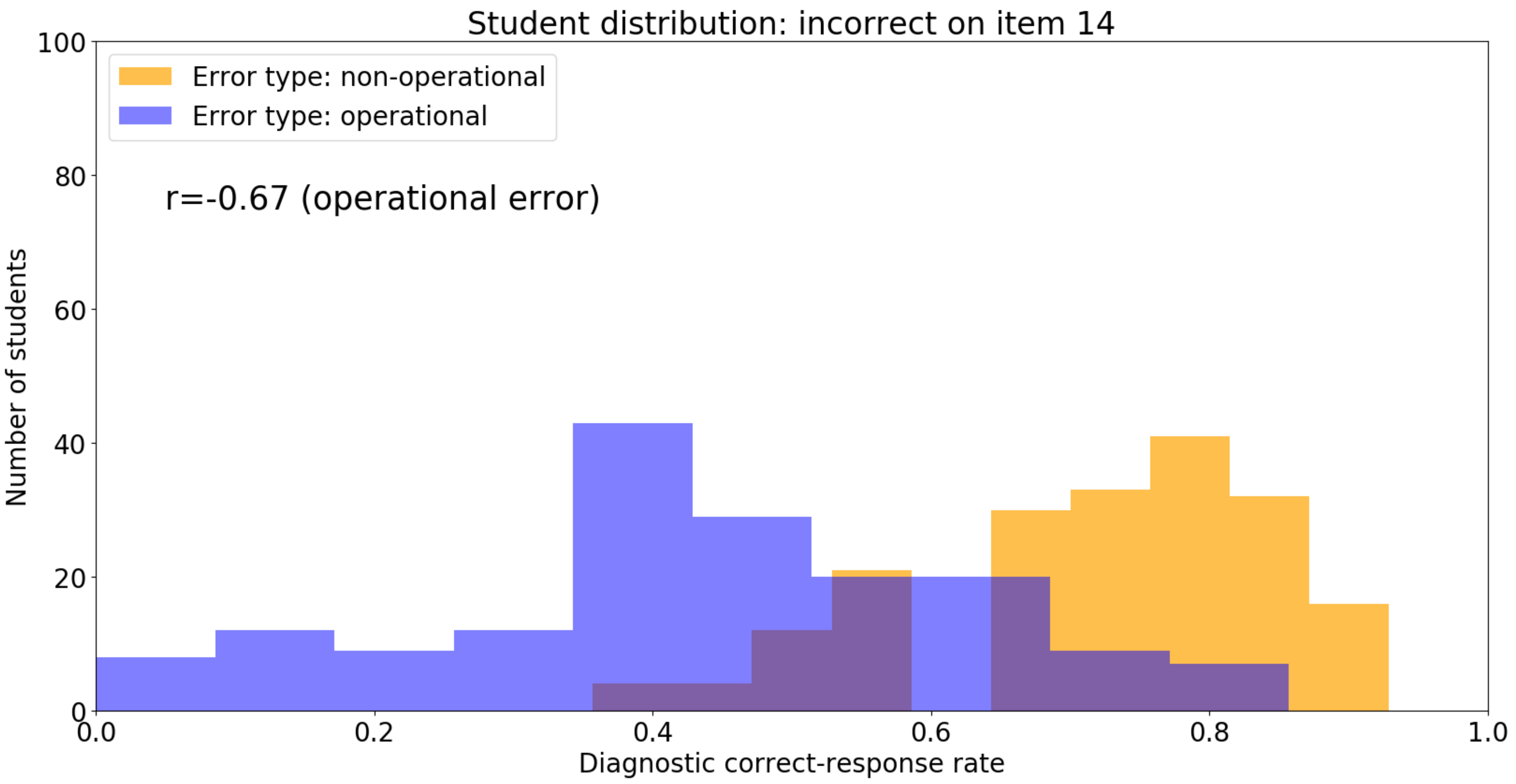


Solve for x.

$$ax + b = cx + d$$

Student correlations with error type





$$v^2 = v_0^2 + 2ad$$

$$v_0 = 0$$

$$a = \frac{v_1}{t_1}$$

$$v = \frac{v_1}{2}$$

$$d = ?$$

Summary

- Course diagnostic performance can be accurately predicted independent of course level, campus, and academic term
- Student diagnostic performance is less predictable, but high correlations are observed
- This strong predictability and correlation amongst diverse student samples, along with high correlations between items, shows that students’ lack of understanding in math seems to represent itself in various mathematics topics to a similar degree