# Interpretation of regression coefficients

Is that textbook overpriced?

```
> head(textbooks)
  deptAbbr course           isbn uclaNew amazNew more  diff
1   Am Ind   C170 978-0803272620   27.67   27.95    Y -0.28
2   Anthro      9 978-0030119194   40.59   31.14    Y  9.45
3   Anthro   135T 978-0300080643   31.68   32.00    Y -0.32
4   Anthro  191HB 978-0226206813   16.00   11.52    Y  4.48
5   Art His  M102K 978-0892365999  18.95   14.21    Y  4.74
6   Art His   118E 978-0394723693  14.95   10.17    Y  4.78
```
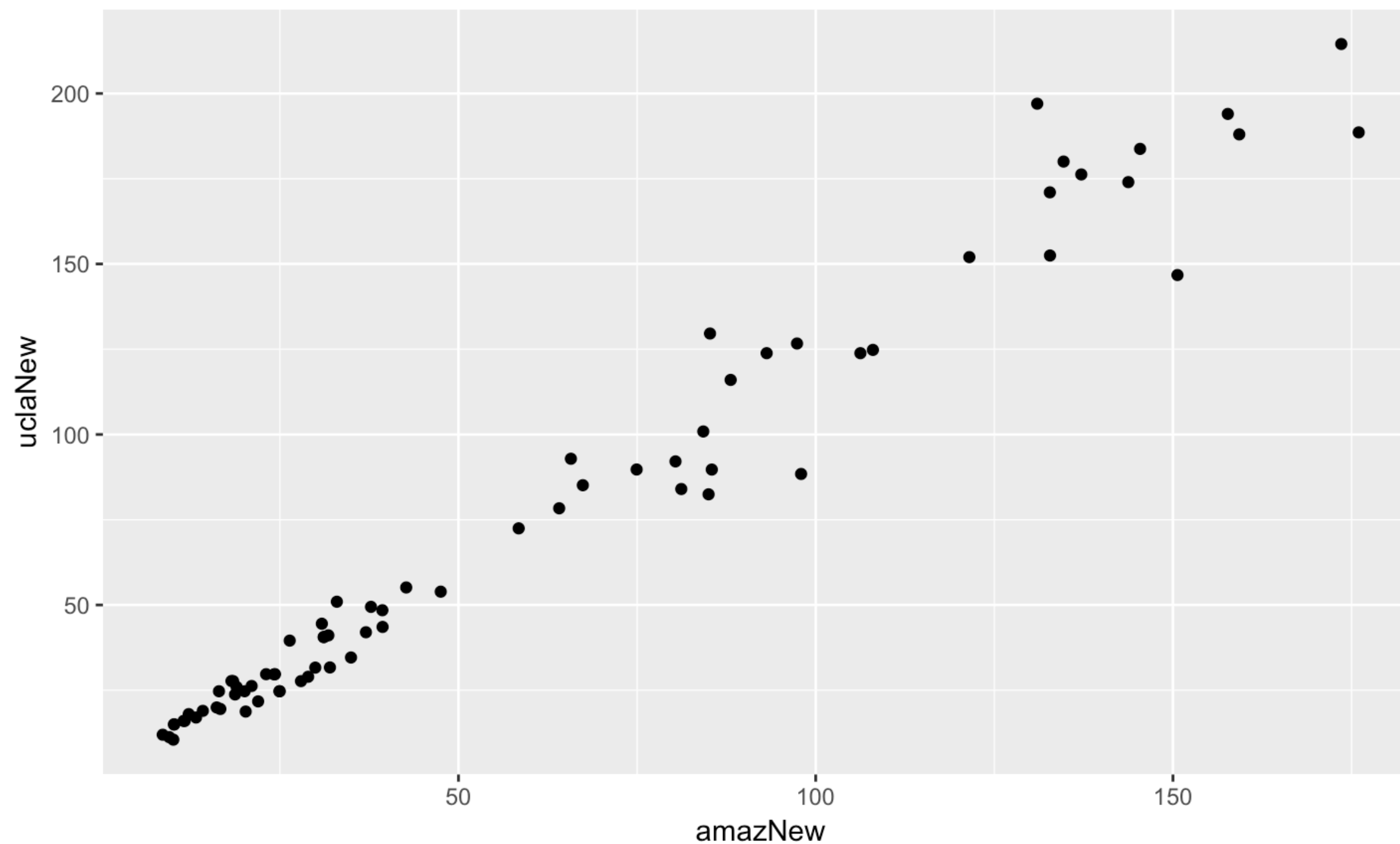
Compared to the course number?

```
> textbooks %>%
    mutate(course_number = readr::parse_number(course)) %>%
    ggplot(aes(x = course_number, y = uclaNew)) +
    geom_point()
```
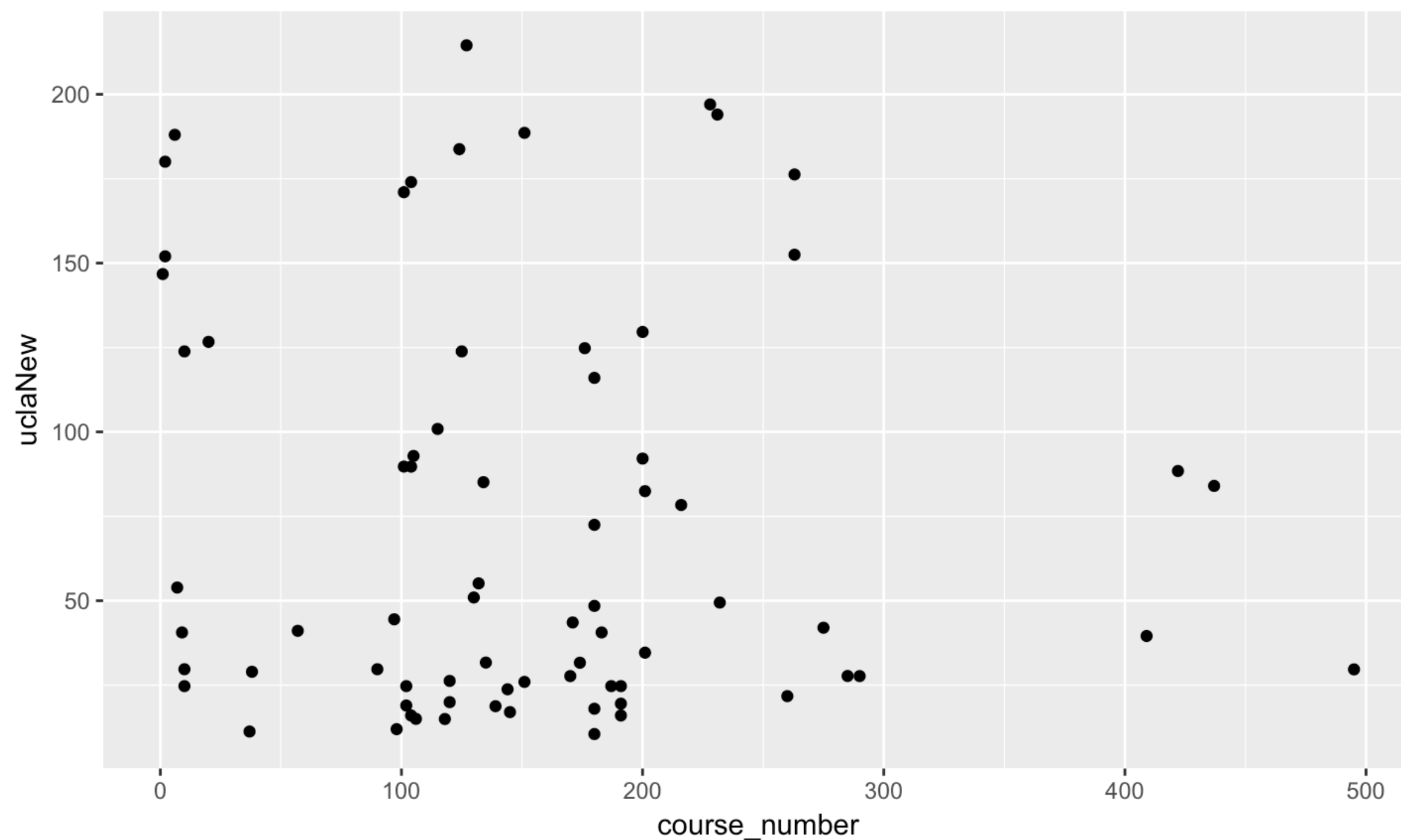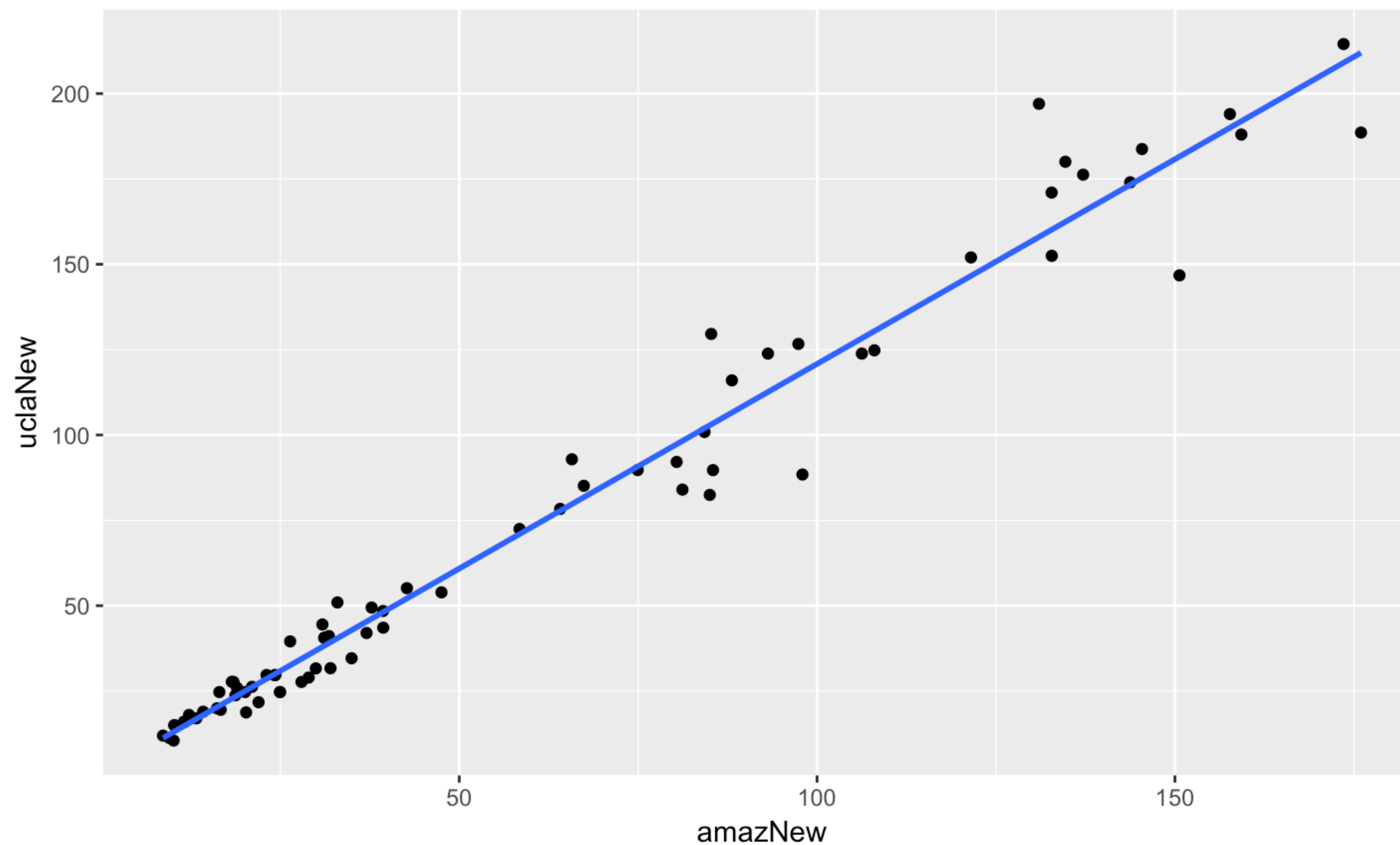
Compared to Amazon?

```
> ggplot(data = textbooks, aes(x = amazNew, y = uclaNew)) +
    geom_point()
```

Compared to Amazon?

```
> ggplot(data = textbooks, aes(x = amazNew, y = uclaNew)) +
    geom_point() + geom_smooth(method = "lm", se = FALSE)
```

Slope and intercept

```
> lm(uclaNew ~ amazNew, data = textbooks)

Call:
lm(formula = uclaNew ~ amazNew, data = textbooks)

Coefficients:
(Intercept)        amazNew
      0.929          1.199
```

$$\widehat{uclaNew} = 0.929 + 1.199 \cdot amazNew$$

Units and scale

```
> textbooks %>%
    mutate(amazNew_cents = amazNew * 100) %>%
    lm(uclaNew ~ amazNew_cents, data = .)

Call:
lm(formula = uclaNew ~ amazNew_cents, data = .)

Coefficients:
(Intercept)   amazNew_cents
      0.929          0.01199
```

CORRELATION AND REGRESSION

Let's practice!

CORRELATION AND REGRESSION

Your linear model object

Is that textbook overpriced?

```
> mod <- lm(uclaNew ~ amazNew, data = textbooks)
> class(mod)
[1] "lm"
```

Print

```
> mod

Call:
lm(formula = uclaNew ~ amazNew, data = textbooks)

Coefficients:
(Intercept)      amazNew
      0.929        1.199
```

Fitted coefficients

```
> coef(mod)
(Intercept)      amazNew
      0.929        1.199
```

Summary

```
> summary(mod)

Call:
lm(formula = uclaNew ~ amazNew, data = textbooks)

Residuals:
    Min      1Q Median      3Q     Max
 -34.78   -4.57    0.58    4.01   39.00

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)    0.9290     1.9354    0.48     0.63
amazNew        1.1990     0.0252   47.60   <2e-16

Residual standard error: 10.5 on 71 degrees of freedom
Multiple R-squared:  0.97,   Adjusted R-squared:  0.969
F-statistic: 2.27e+03 on 1 and 71 DF,  p-value: <2e-16
```

Fitted values

```
> fitted.values(mod)
     1       2       3       4       5       6       7       8       9      10
 34.44   38.27   39.30   14.74   17.97   13.12   24.98   20.90  128.32   16.83
    11      12      13      14      15      16      17      18      19      20
 36.84  106.55   23.05   20.68  117.69   57.89   90.77  160.12  146.61  130.42
    21      22      23      24      25      26      27      28      29      30
 14.92   23.64   15.60   27.25   38.27   35.64   20.29   46.19   39.03   40.46
    31      32      33      34      35      36      37      38      39      40
 37.94  102.84   42.83  118.37   98.26   12.32   13.16  162.42  173.29  211.95
    41      42      43      44      45      46      47      48      49      50
181.53  175.26  209.03  158.00  189.99  165.40   30.84  191.91   28.59   26.16
    51      52      53      54      55      56      57      58      59      60
 52.10   48.13  103.08  112.59   81.74  160.14   30.08   30.84  103.38   13.01
    61      62      63      64      65      66      67      68      69      70
 79.74  101.96   11.24   70.97   97.29   77.77   45.34   25.16   48.10   32.55
    71      72      73
 29.93   23.37   22.77
```

Residuals

```
> residuals(mod)
        1           2           3           4           5           6           7
-6.77105     2.32413    -7.61701     1.25854     0.98322     1.82719    -0.28093
        8           9          10          11          12          13          14
-1.40433    -4.48287     0.17228    -5.20906     9.45100     4.61946     4.02348
       15          16          17          18          19          20          21
 8.98228    -3.99352    -1.04014    10.87962     5.39236    -5.62112     1.07869
       22          23          24          25          26          27          28
 2.31195     2.39526    -5.51705     2.32413    -6.69006    -0.34284     3.25873
       29          30          31          32          33          34          35
 2.05677    10.48996     6.55786   -20.39409    -8.23406   -29.95115   -14.26390
       36          37          38          39          40          41          42
-1.06948     1.84122    17.60753     0.71458   -23.37321   -34.78455     8.48623
       43          44          45          46          47          48          49
 5.47235    39.00185     4.01249    10.85401    -6.14405    -3.90591     1.11007
       50          51          52          53          54          55          56
 0.08405     3.02765    -4.57365    26.51611    11.24803     3.37834    -7.66436
...
```

broom

```
> library(broom)
> augment(mod)
   uclaNew amazNew .fitted .se.fit    .resid     .hat .sigma   .cooksd
1    27.67   27.95   34.44   1.460  -6.77105 0.01944 10.515 4.227e-03
2    40.59   31.14   38.27   1.418   2.32413 0.01834 10.543 4.687e-04
3    31.68   32.00   39.30   1.407  -7.61701 0.01806 10.507 4.955e-03
4    16.00   11.52   14.74   1.721   1.25854 0.02700 10.546 2.059e-04
5    18.95   14.21   17.97   1.674   0.98322 0.02555 10.546 1.186e-04
6    14.95   10.17   13.12   1.745   1.82719 0.02776 10.545 4.469e-04
7    24.70   20.06   24.98   1.577  -0.28093 0.02268 10.547 8.544e-06
8    19.50   16.66   20.90   1.632  -1.40433 0.02430 10.546 2.295e-04
9   123.84  106.25  128.32   1.700  -4.48287 0.02637 10.533 2.548e-03
10   17.00   13.26   16.83   1.690   0.17228 0.02605 10.547 3.716e-06
11   31.63   29.95   36.84   1.433  -5.20906 0.01874 10.528 2.407e-03
12  116.00   88.09  106.55   1.422   9.45100 0.01844 10.485 7.794e-03
13   27.67   18.45   23.05   1.603   4.61946 0.02343 10.532 2.390e-03
14   24.70   16.47   20.68   1.636   4.02348 0.02439 10.536 1.891e-03
15  126.67   97.38  117.69   1.554   8.98228 0.02202 10.491 8.468e-03
```

Let's practice!

Using the linear model

Is that textbook overpriced?

```
> mod <- lm(uclaNew ~ amazNew, data = textbooks)
```

Examining residuals

```
> library(broom)
> augment(mod) %>%
    arrange(desc(.resid)) %>%
    head()
  uclaNew amazNew .fitted .se.fit .resid    .hat .sigma .cooksd .std.resid
1  197.00  131.00  158.00   2.179  39.00 0.04331  9.409 0.32816      3.808
2  129.60   85.20  103.08   1.387  26.52 0.01753 10.051 0.05822      2.554
3  180.03  134.69  162.42   2.257  17.61 0.04644 10.324 0.07219      1.722
4   92.88   65.73   79.74   1.236  13.14 0.01393 10.428 0.01128      1.264
5  123.84   93.13  112.59   1.491  11.25 0.02026 10.459 0.01217      1.085
6  171.00  132.77  160.12   2.216  10.88 0.04479 10.463 0.02649      1.063
```
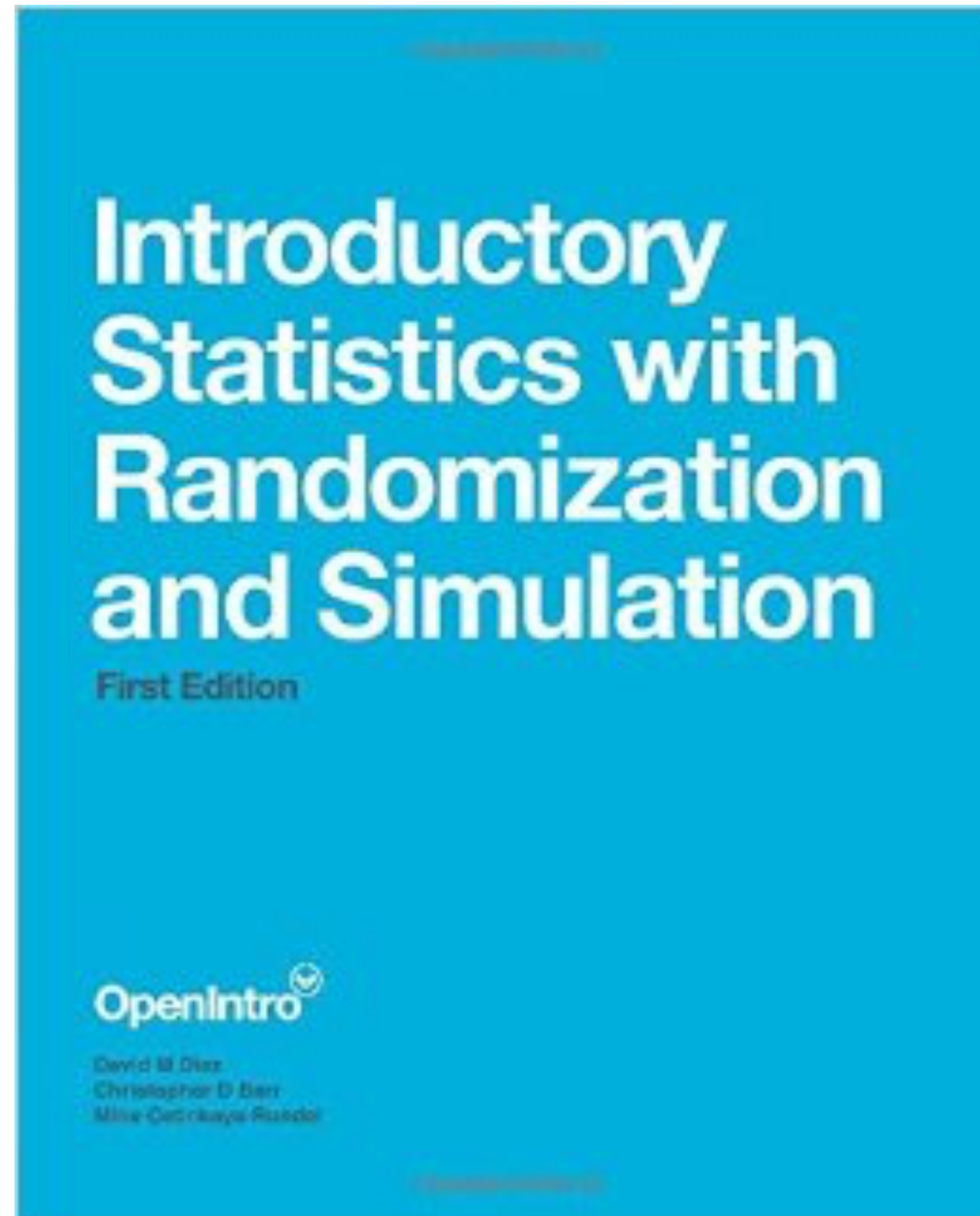
Markup

```
> textbooks %>%
    filter(uclaNew == 197)
  deptAbbr course            ibsn uclaNew  amazNew more diff
1    Mgmt    228 978-0073379661     197      131    Y   66
```
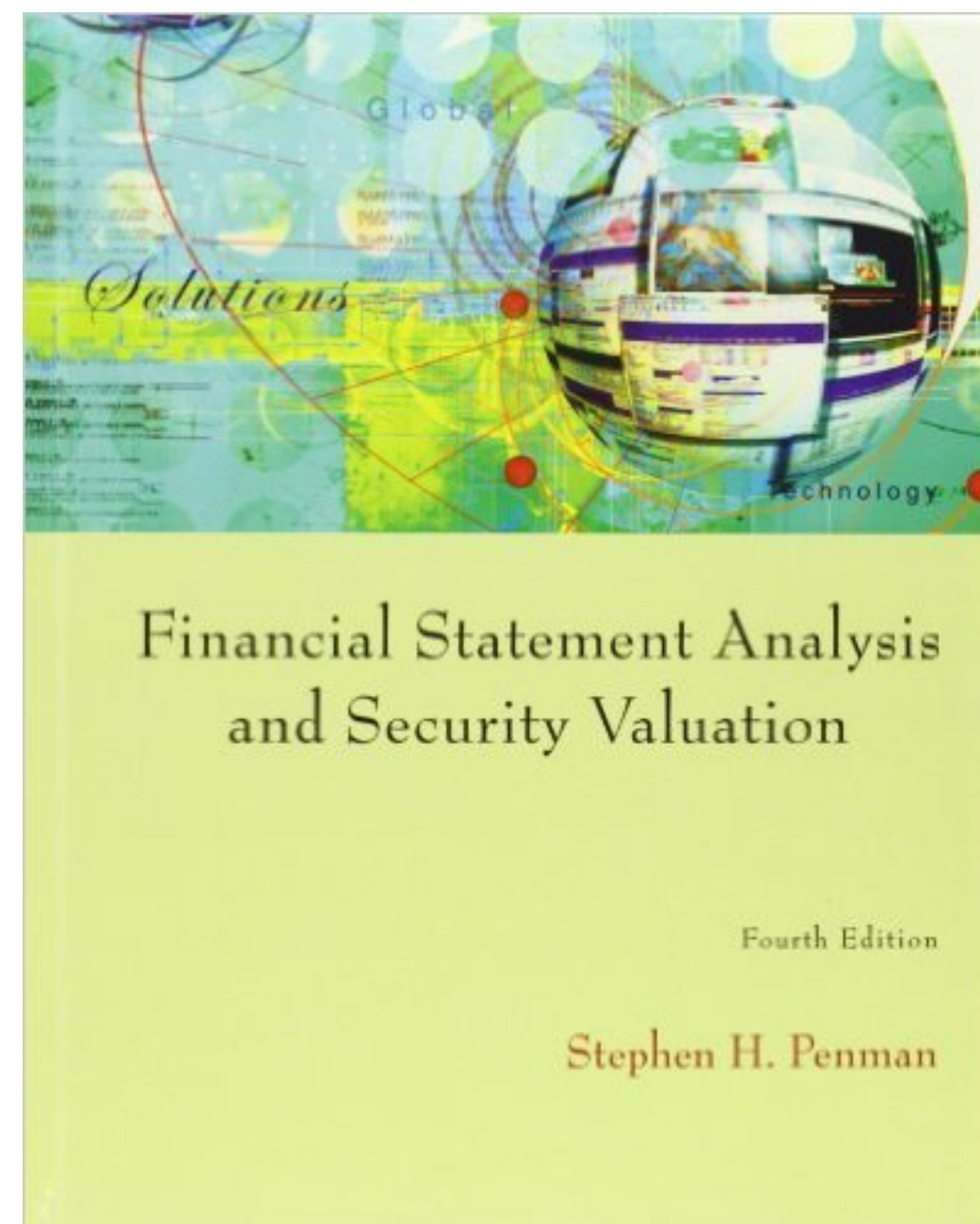
Making predictions

Making predictions

`predict(lm)`

↓

fitted values for existing data

Making predictions

`predict(lm, newdata)`

fitted values for any new data
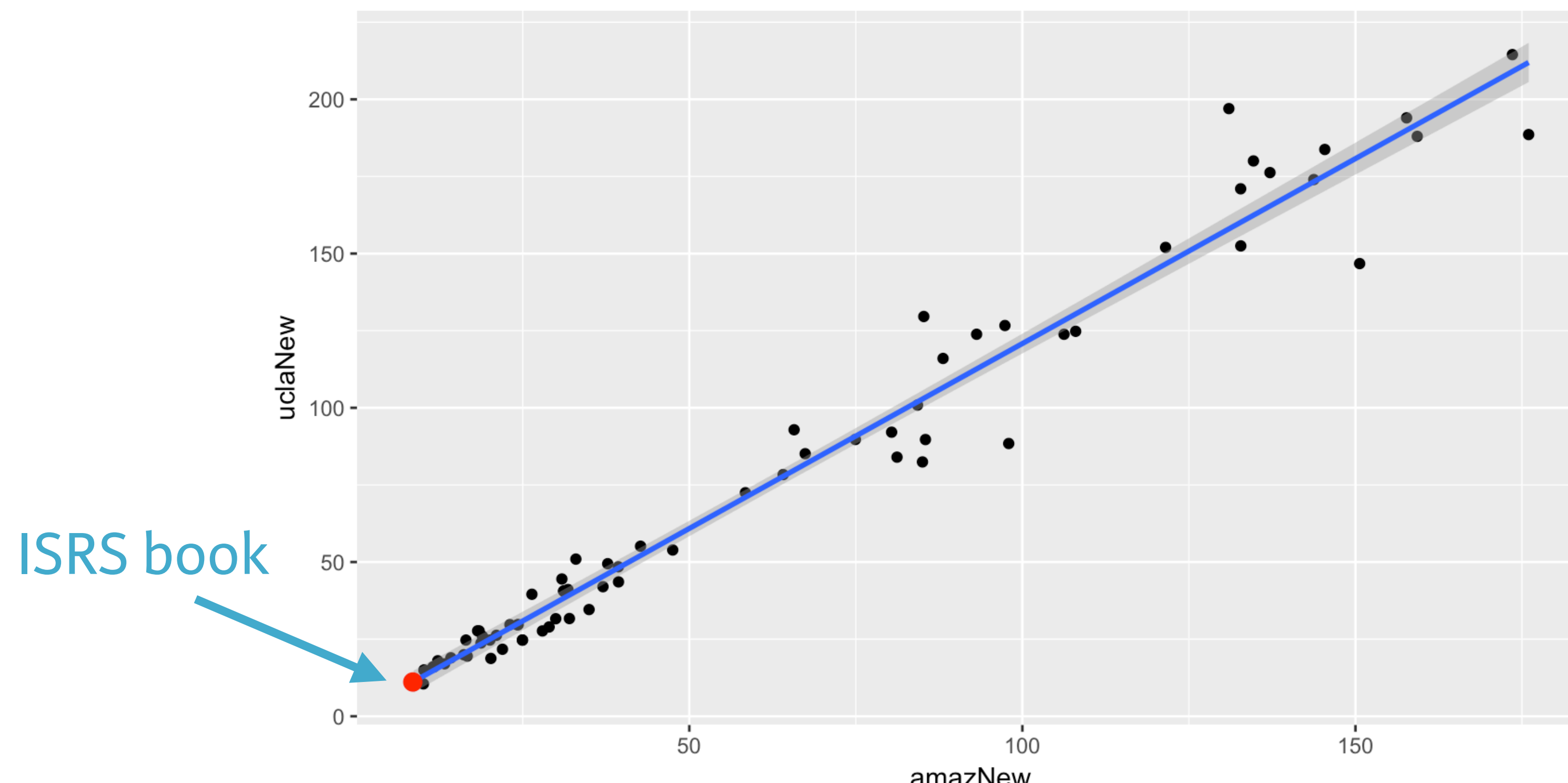
New data

```
> new_data <- data.frame(amazNew = 8.49)
> predict(mod, newdata = new_data)
    1
11.11
```

Visualize new observations

```
> isrs <- broom::augment(mod, newdata = new_data)
> ggplot(data = textbooks, aes(x = amazNew, y = uclaNew)) +
    geom_point() + geom_smooth(method = "lm") +
    geom_point(data = isrs, aes(y = .fitted), size = 3, color = "red")
```


ISRS book

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Let's practice!