Using Assessment System Data to Generate Individualized Learning Materials for Students

What We Learned from Developing the iDAP

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A presentation at the 19th MARC conference, Nov. 7, 2019

Overview

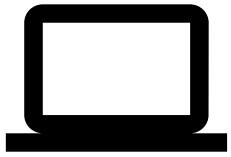
1. Background
   - AP-CAT
   - iDAP
2. Lessons learned
   - Teacher Access & Teacher Engagement
   - Plan for Heterogeneity
   - Toolchain
   - Quality Control
   - Process Data
3. Future
   - Learning Modules

Background

AP-CAT

- Full Name: “Cognitive Diagnostic Computerized Adaptive Testing (CD-CAT) for AP Statistics”
- A five-year CAREER project funded by the National Science Foundation
- Two major components
  - Research
  - Educational outreach

Development

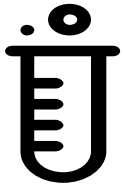


Item Bank
Web Platform

Refinement

Mobile
Diagnostic Score Report
Pilot Data

RCT



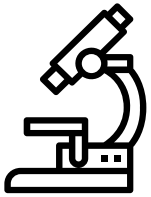
Feedback Types
Learning Outcomes

2015 2016 2017 2018 2019

Testing

Bugs
UX/UI
Item Keys

Observation



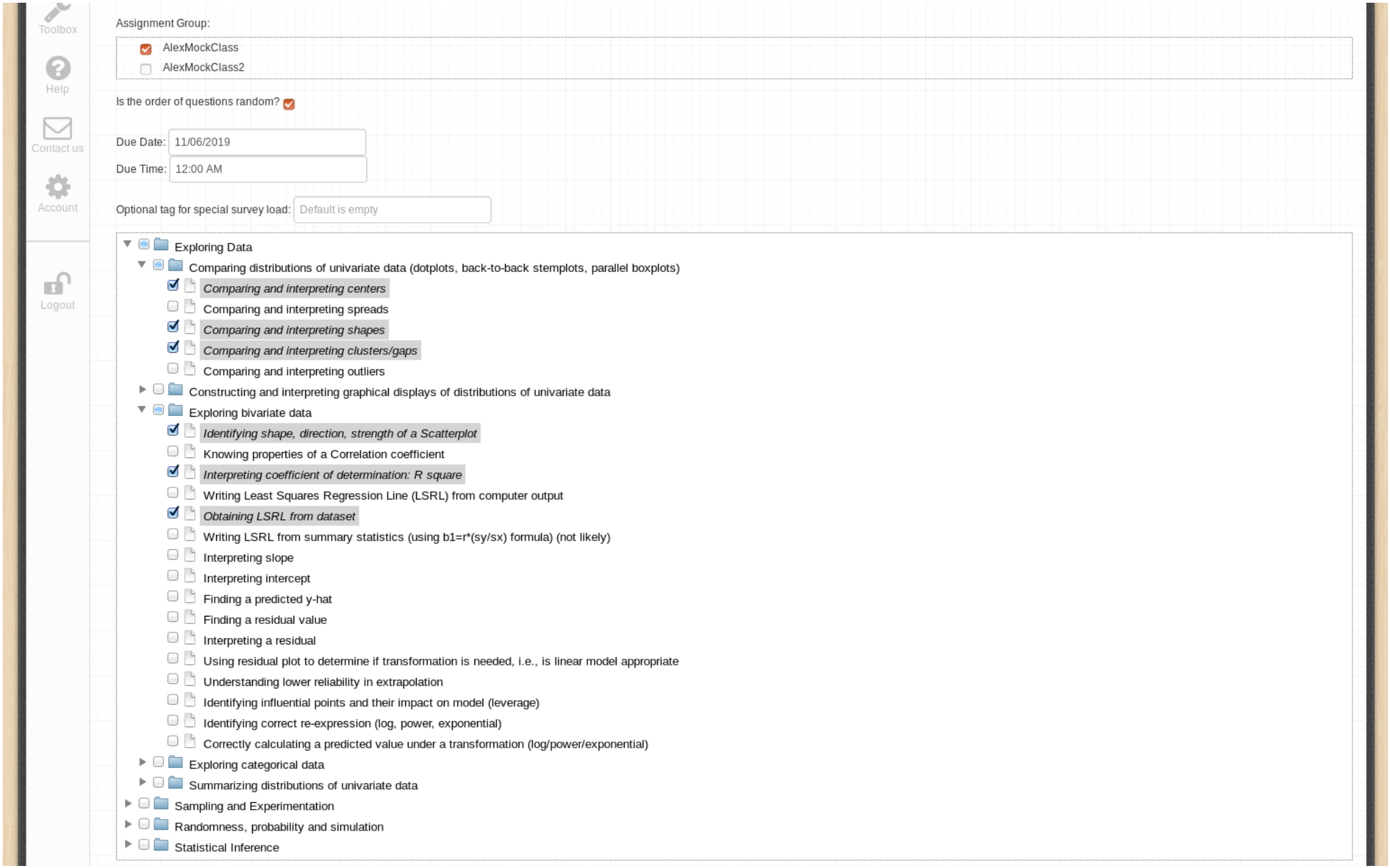
Engagement Survey
Item Calibration
Adaptive Testing

Item Bank

- 850 items
  - 4 sections
  - 16 main topics
  - 158 attributes

All Questions

#	Question	Creator	Type	Status	Attributes	Time Created	Operation
1	Temperature Boxplot Median Qid: 1	Alison_Cheng	Multiple Choice	Updated	Statistics - 1.C.1.	Jul 28, 2014 - 10:48 p.m.	Review | Edit | Delete
2	Temperature Boxplot Percentile Qid: 2	Alison_Cheng	Multiple Choice	Approved	Statistics - 1.B.17.	Jul 29, 2014 - 10:11 a.m.	Review | Edit | Delete
3	Temperature Summary Outlier 1 Qid: 3	Alison_Cheng	Blank Field	Updated	Statistics - 1.B.5.	Jul 29, 2014 - 10:14 a.m.	Review | Edit | Delete
4	Temperature Summary Outlier 2 Qid: 4	Alison_Cheng	Blank Field	Updated	Statistics - 1.B.5.	Jul 29, 2014 - 10:16 a.m.	Review | Edit | Delete
5	Empirical Rule Area Qid: 5	Alison_Cheng	Blank Field	Updated	Statistics - 3.C.1.	Jul 29, 2014 - 10:18 a.m.	Review | Edit | Delete
6	Donut Probability 1 Qid: 6	Alison_Cheng	Blank Field	Updated	Statistics - 1.B.10.	Jul 29, 2014 - 10:21 a.m.	Review | Edit | Delete
7	Donut Probability 2 Qid: 7	Alison_Cheng	Blank Field	Updated	Statistics - 3.A.4.	Jul 29, 2014 - 10:38 a.m.	Review | Edit | Delete


Toolbox
Help
Contact us
Account
Logout
Assignment Group:
AlexMockClass
AlexMockClass2
Is the order of questions random?
Due Date: 11/06/2019
Due Time: 12:00 AM
Optional tag for special survey load: Default is empty
Exploring Data
Comparing distributions of univariate data (dotplots, back-to-back stemplots, parallel boxplots)
Comparing and interpreting centers
Comparing and interpreting spreads
Comparing and interpreting shapes
Comparing and interpreting clusters/gaps
Comparing and interpreting outliers
Constructing and interpreting graphical displays of distributions of univariate data
Exploring bivariate data
Identifying shape, direction, strength of a Scatterplot
Knowing properties of a Correlation coefficient
Interpreting coefficient of determination: R square
Writing Least Squares Regression Line (LSRL) from computer output
Obtaining LSRL from dataset
Writing LSRL from summary statistics (using b1=r*(sy/sx) formula) (not likely)
Interpreting slope
Interpreting intercept
Finding a predicted y-hat
Finding a residual value
Interpreting a residual
Using residual plot to determine if transformation is needed, i.e., is linear model appropriate
Understanding lower reliability in extrapolation
Identifying influential points and their impact on model (leverage)
Identifying correct re-expression (log, power, exponential)
Correctly calculating a predicted value under a transformation (log/power/exponential)
Exploring categorical data
Summarizing distributions of univariate data
Sampling and Experimentation
Randomness, probability and simulation
Statistical Inference

AP-CAT

Welcome abroders

Home

My tests

Help

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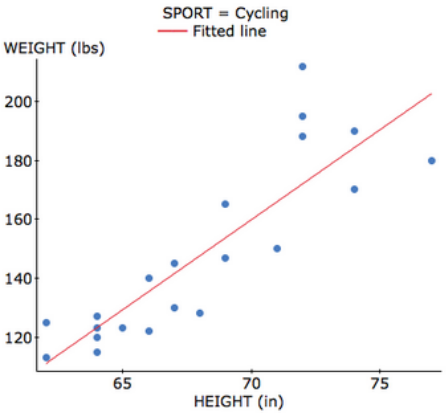
Question 1/1 Show All

Save and resume later

The heights and weights of the 2016 USA Olympic cycling team are graphed below. We can predict an Olympian's weight from their height using the least squares regression equation below:

WEIGHT = -267 + 6.1 HEIGHT (in).



Interpret the y-intercept in context.

A. This model predicts that a cyclist who is zero inches tall will weigh around -267 pounds.

B. This model predicts that a cyclist who is zero inches tall will weigh around 110 pounds.

C. This model predicts that a cyclist who weighs zero pounds will be -267 inches tall.

D. This model predicts that a cyclist who weighs zero pounds will be around 110 inches tall.

E. This model predicts that a cyclist who weighs zero pounds will be around 61 inches tall.

Next

Scaffolding

- Step-by-step Solutions
  - Visible after assignment completion

	Aerobics Class IQR Interpretation	The middle 50% of ages of aerobics participants has a range of 9.	The middle 25% of ages of the aerobics participants is between 23.5 and 28.5.	3 s

In a random sample of 24 people in an aerobics class, their ages are given as follows:

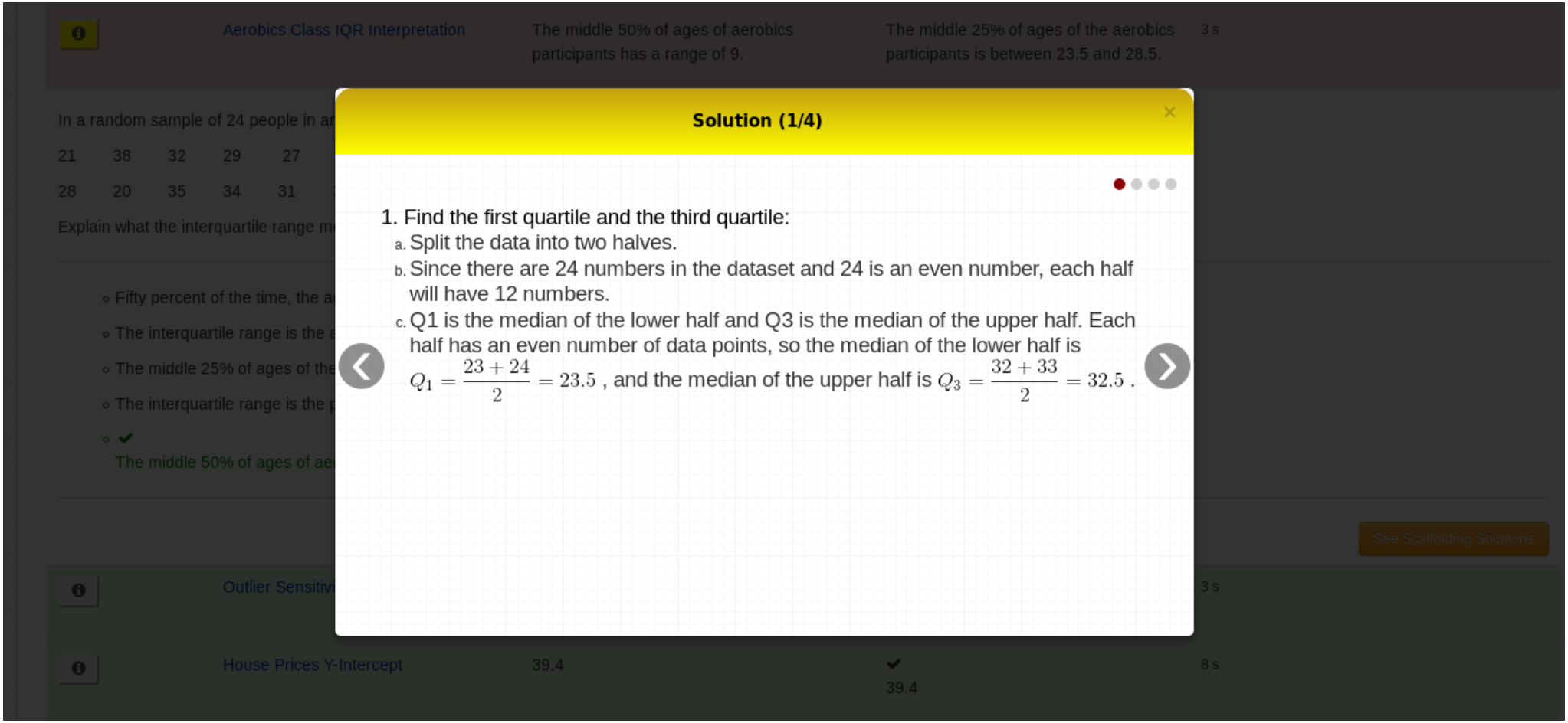
21	38	32	29	27	27	46	18	24	23	30	31
28	20	35	34	31	29	19	48	28	25	22	33

Explain what the interquartile range means for these data.

- Fifty percent of the time, the age of an aerobics participant is between 23.5 and 32.5 years old.
- The interquartile range is the average range of the ages of participants in this aerobics class.
- The middle 25% of ages of the aerobics participants is between 23.5 and 28.5.
- The interquartile range is the participants' average distance away from the mean age.
- ✔
  The middle 50% of ages of aerobics participants has a range of 9.

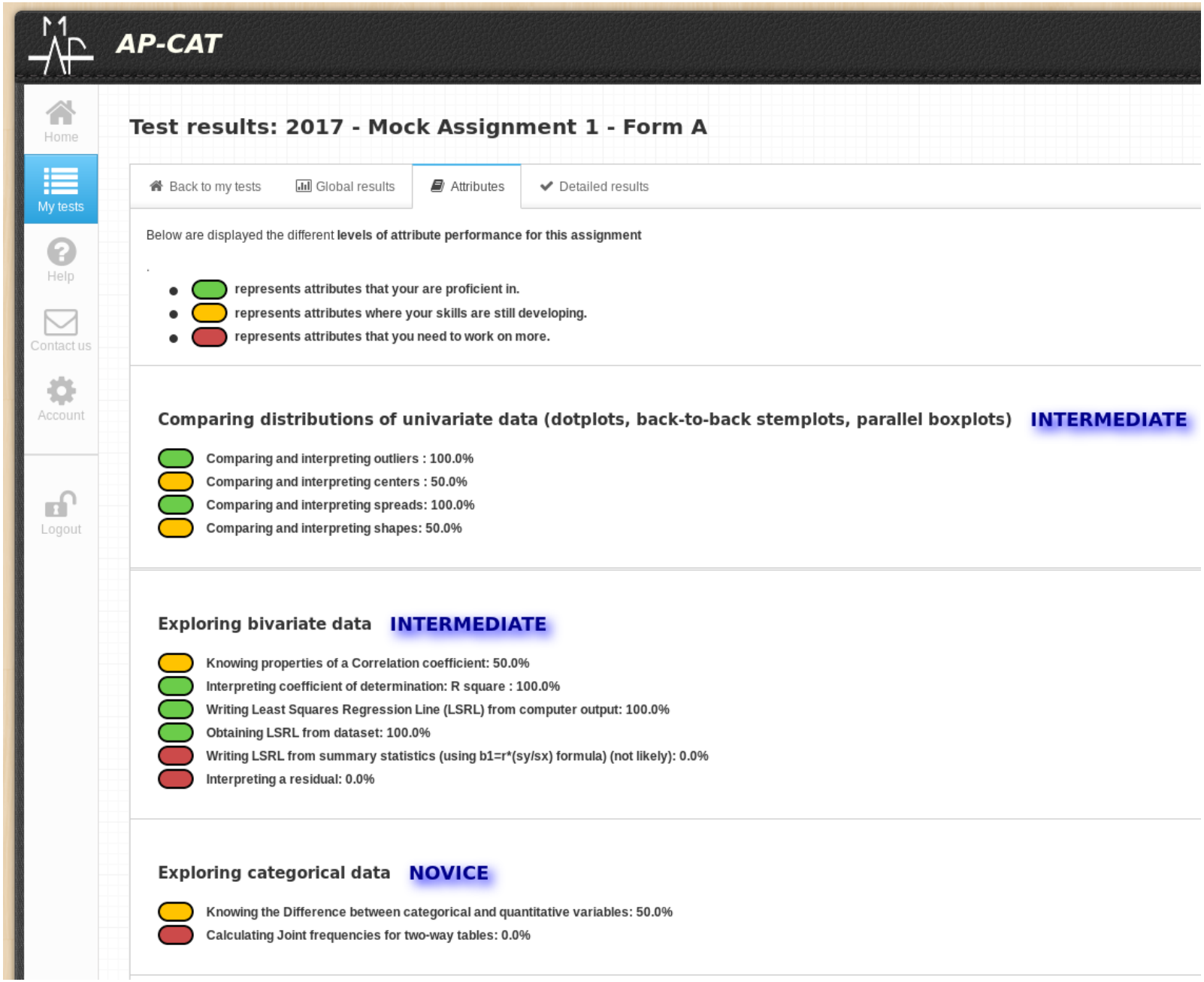
See Scaffolding Solutions

	Outlier Sensitivity	Standard Deviation	✔ Standard Deviation	3 s
	House Prices Y-Intercept	39.4	✔ 39.4	8 s


Aerobics Class IQR Interpretation
The middle 50% of ages of aerobics participants has a range of 9.
The middle 25% of ages of the aerobics participants is between 23.5 and 28.5.
3 s
In a random sample of 24 people in ar
21 38 32 29 27
28 20 35 34 31
Explain what the interquartile range m
Fifty percent of the time, the a
The interquartile range is the
The middle 25% of ages of the
The interquartile range is the
The middle 50% of ages of ae
Solution (1/4)
1. Find the first quartile and the third quartile:
a. Split the data into two halves.
b. Since there are 24 numbers in the dataset and 24 is an even number, each half will have 12 numbers.
c. Q1 is the median of the lower half and Q3 is the median of the upper half. Each half has an even number of data points, so the median of the lower half is $Q_1 = \frac{23+24}{2} = 23.5$, and the median of the upper half is $Q_3 = \frac{32+33}{2} = 32.5$.
See Scaffolding Solutions
Outlier Sensitiv
3 s
House Prices Y-Intercept
39.4
39.4
8 s

Feedback

- Granular feedback
  - Areas of opportunity


AP-CAT
Home
My tests
Help
Contact us
Account
Logout
Test results: 2017 - Mock Assignment 1 - Form A
Back to my tests
Global results
Attributes
Detailed results
Below are displayed the different levels of attribute performance for this assignment
represents attributes that your are proficient in.
represents attributes where your skills are still developing.
represents attributes that you need to work on more.
Comparing distributions of univariate data (dotplots, back-to-back stemplots, parallel boxplots) INTERMEDIATE
Comparing and interpreting outliers : 100.0%
Comparing and interpreting centers : 50.0%
Comparing and interpreting spreads: 100.0%
Comparing and interpreting shapes: 50.0%
Exploring bivariate data INTERMEDIATE
Knowing properties of a Correlation coefficient: 50.0%
Interpreting coefficient of determination: R square : 100.0%
Writing Least Squares Regression Line (LSRL) from computer output: 100.0%
Obtaining LSRL from dataset: 100.0%
Writing LSRL from summary statistics (using b1=r*(sy/sx) formula) (not likely): 0.0%
Interpreting a residual: 0.0%
Exploring categorical data NOVICE
Knowing the Difference between categorical and quantitative variables: 50.0%
Calculating Joint frequencies for two-way tables: 0.0%

iDAP

- Intelligent Diagnostic Assessment Platform (i-DAP) for High School Statistics Education
  - GOAL: Develop a holistic, personalized, learning system integrated into the classroom

iDAP

- Leverage attribute system developed in the AP-CAT
  - Map to 36 common core state standards on “statistics and probability”


iDAP
AP-CAT

Lessons learned

Lesson 1

Teacher Access & Teacher Engagement

Teacher Access & Teacher Engagement

- Teacher approval
  - delivery engine
  - reporting
  - feature requests
  - rollout of assignments
    - Example: In-Class Assignment Length

Lesson 2

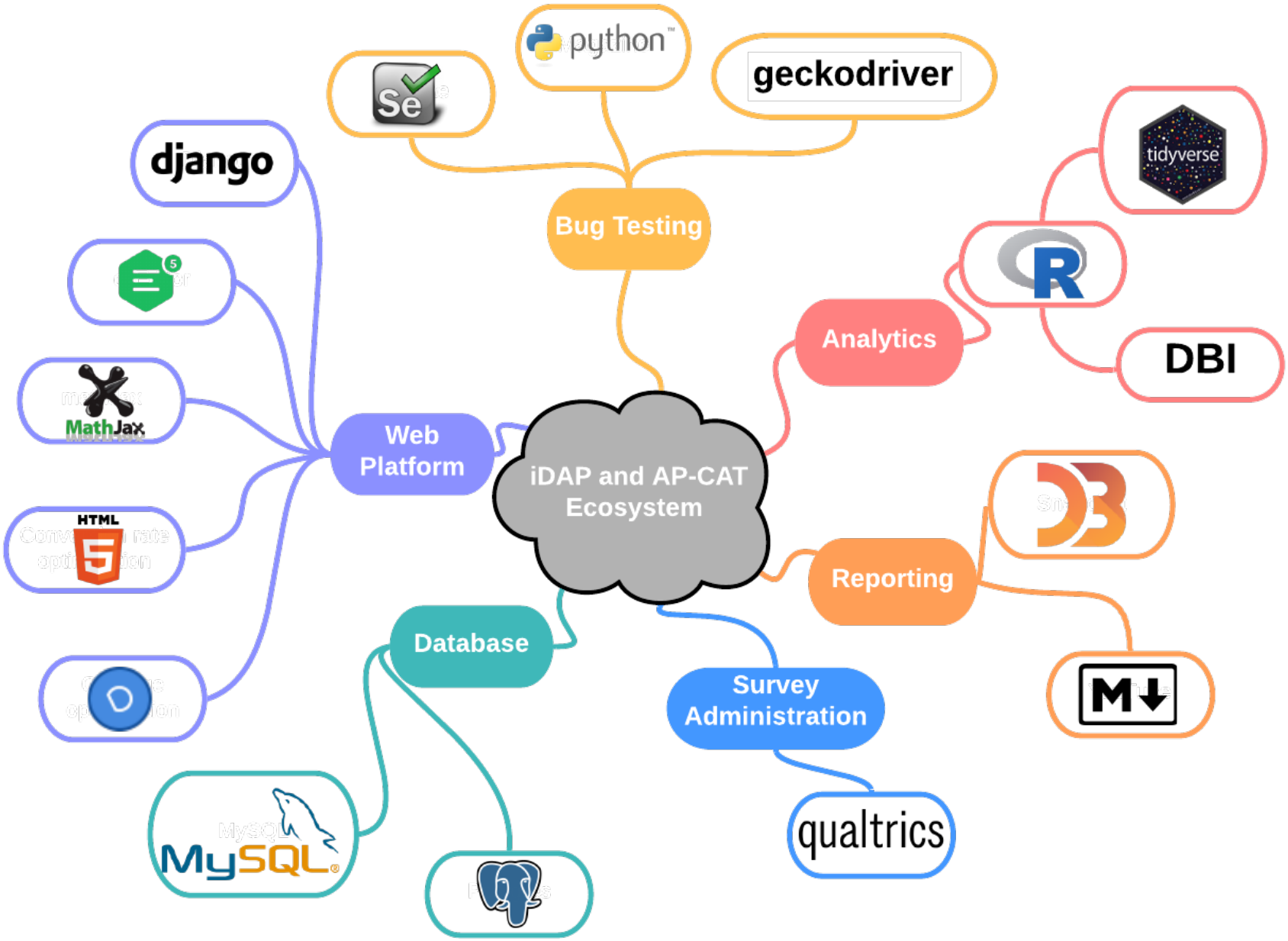
- Plan for Heterogeneity
  - in learning environment
  - in students

Sample Heterogeneity

- Not surprising
  - learning outcomes depend on school
- Surprising
  - Student self-predictions of their final exam scores depend on school (Ober et al., In Prep)
  - Patterns of incorrect responses

Lesson 3

Choose your toolchain wisely


iDAP and AP-CAT Ecosystem
Web Platform
Bug Testing
Analytics
Reporting
Database
Survey Administration
python
geckodriver
django
tidyverse
DBI
MathJax
HTML
MySQL
qualtrics

```
con <- DBI::dbConnect(RMySQL::MySQL(), ## Connect to DB
      host = "domain.name.edu",
      port = 3306,
      user = "db_user",
      password = "db_pw",
      dbname = "db_name")

tbl(con, "activity") %>%
      filter(role == "student") %>% ## Only student data
      select(-firstname, -lastname, ## de-identify
      -role, -username,
      -id, -meta)

```

Lesson 4

Have Quality Control and Contingency Plans

Lesson 4

- Not all data are worth being collected
- Not all data that have been collected are worth being analyzed

```
# Source:   lazy query [?? x 4]
# Database: mysql 5.7.27-0ubuntu0.18.04.1
#   [user@domain.name:/dname]
   url            tabname            t                   info
   <chr>          <chr>              <chr>               <chr>
1  /results/461   results(student)    2019-09-25 11:30:28  <NA>
2  /results/461   results(student)    2019-09-25 11:30:30  <NA>
3  /results/461   student_info_btn    2019-09-25 11:30:34  "btn":"info","qid":
4  /results/461   student_info_btn    2019-09-25 11:30:36  "btn":"info","qid":
5  /results/461   student_info_btn    2019-09-25 11:31:30  "btn":"info","qid":
6  /results/461   student_info_btn    2019-09-25 11:31:38  "btn":"info","qid":
7  /results/461   Attributes(student) 2019-09-25 11:33:20  <NA>
8  /results/461   results(student)    2019-09-25 11:33:29  <NA>
9  /results/787   results(student)    2019-09-25 11:43:31  <NA>
10 /results/787   results(student)    2019-09-25 11:46:55  <NA>
# ... with many, many, many more rows
```

Lesson 4

- Quality Control
  - Dummy items
  - Response time data (Qualtrics hack)
  - Open text responses to surveys
- Contingency Plan
  - End users are used to having "delete" mean "put in trash"
  - Choosing not to take the exam

Lesson 5

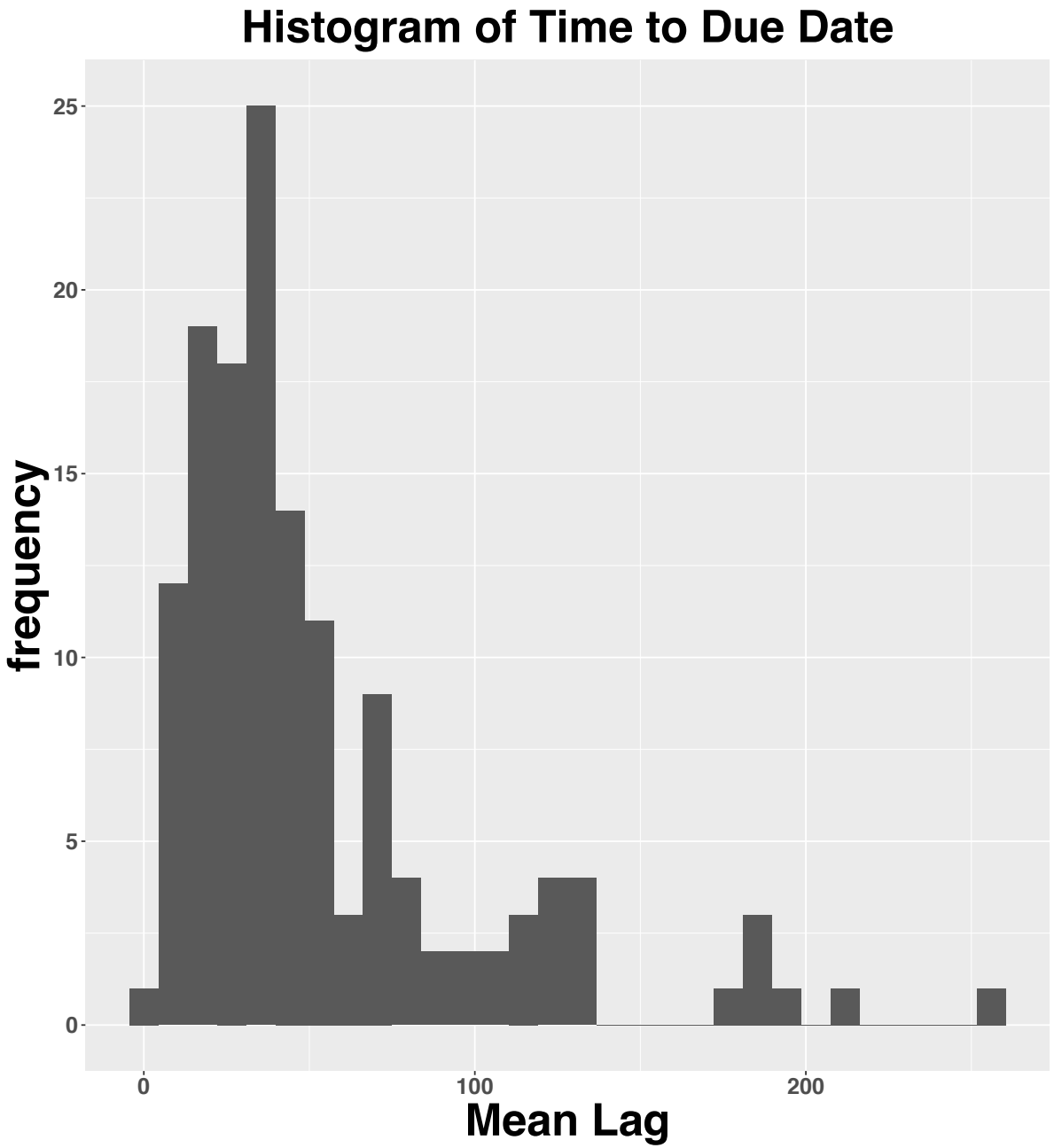
System paradata (Process data) can provide a wealth of information

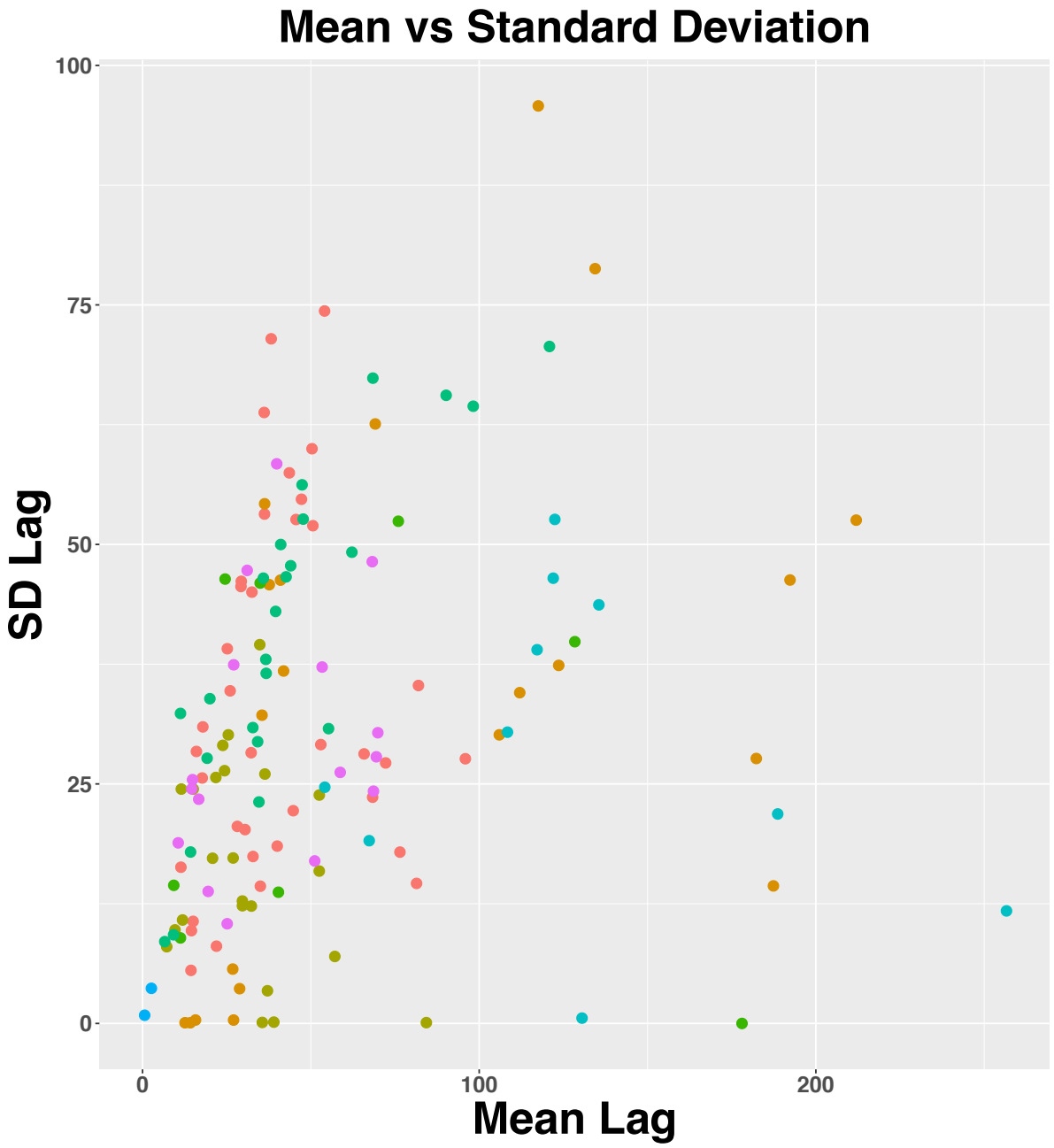
Example: Procrastination

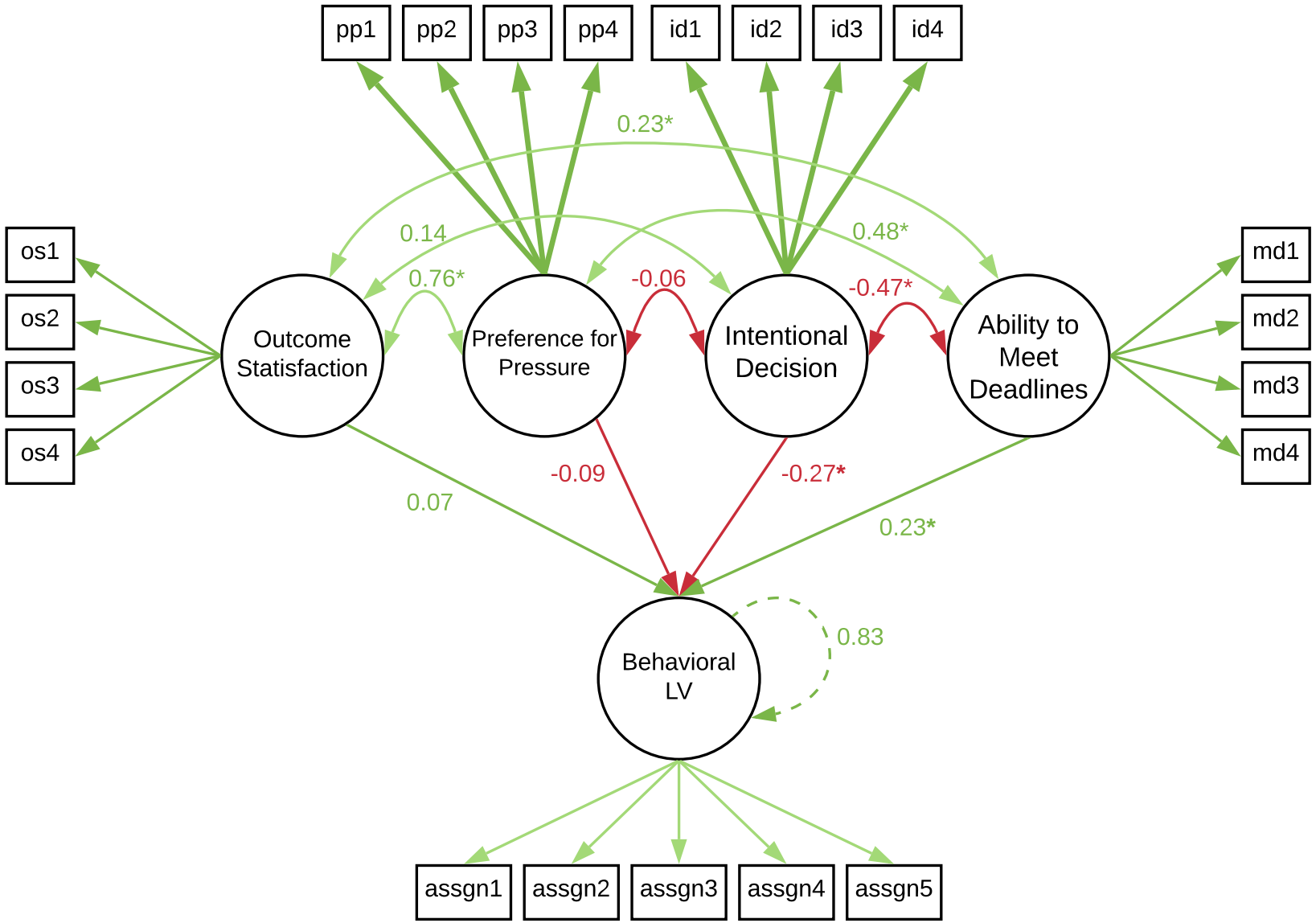
- Active Procrastination (Chu & Choi, 2005)
  - Criticisms (e.g. Delay?) (Krause & Freund, 2014)
- Attempting to validate a survey scale via process data

Data Source

- Data
  - lag = Assignment Deadline - Assignment Submission Time
  - across 5 Assignments
  - Active Procrastination Scale
- Modeling lag as a behavioral indicator of procrastination


Histogram of Time to Due Date
frequency
25
20
15
10
5
0
0
100
200
Mean Lag


Mean vs Standard Deviation
SD Lag
Mean Lag
100
75
50
25
0
0
100
200


pp1
pp2
pp3
pp4
id1
id2
id3
id4
0.23*
0.14
0.76*
-0.06
0.48*
-0.47*
os1
os2
os3
os4
Outcome Statisfaction
Preference for Pressure
Intentional Decision
Ability to Meet Deadlines
md1
md2
md3
md4
-0.09
-0.27*
0.07
0.23*
Behavioral LV
0.83
assgn1
assgn2
assgn3
assgn4
assgn5

Model Fit

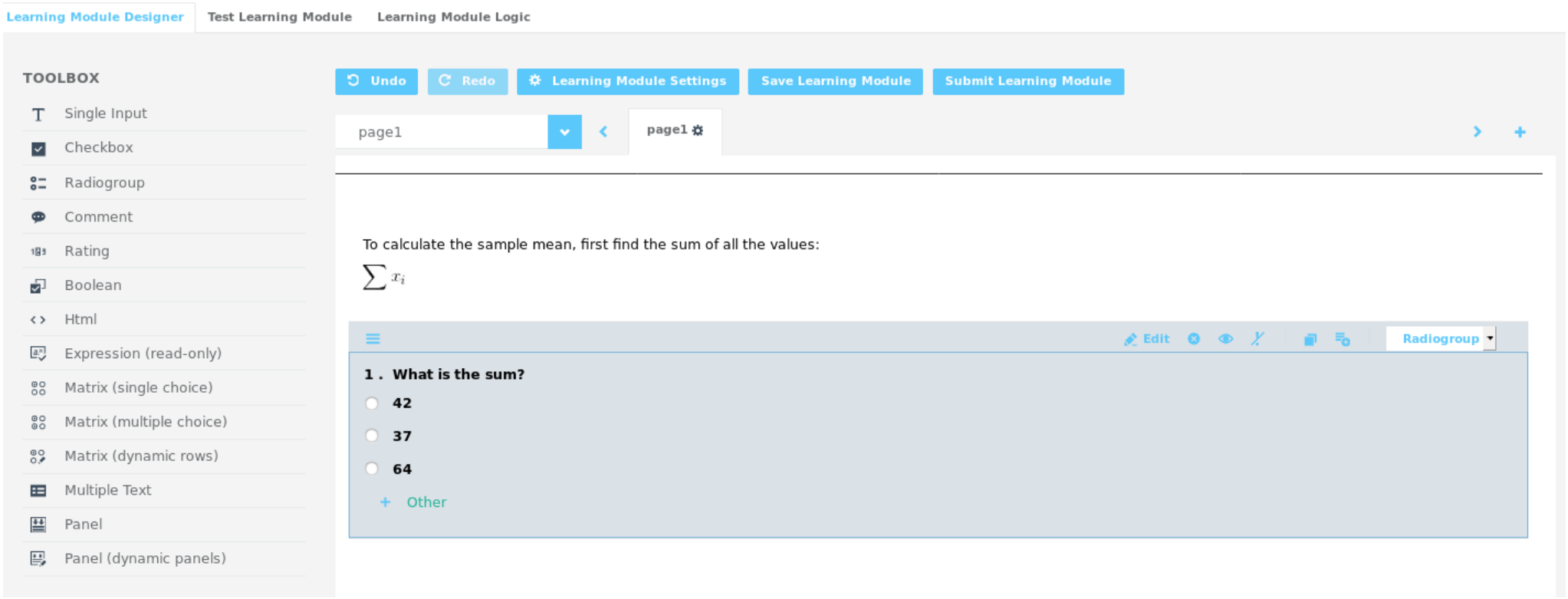
Model Fit

Model	cfi	tli	rmsea (5%)	rmsea (95%)	srmr
Active Procrastination	0.964	0.957	0.074	0.082	0.071

Summary

- Summary
- Limitations
- Future Studies
  - Estimate Latent Procrastination to provide reminders
  - Other applications

Future


Learning Module Designer
Test Learning Module
Learning Module Logic
TOOLBOX
Single Input
Checkbox
Radiogroup
Comment
Rating
Boolean
Html
Expression (read-only)
Matrix (single choice)
Matrix (multiple choice)
Matrix (dynamic rows)
Multiple Text
Panel
Panel (dynamic panels)
Undo
Redo
Learning Module Settings
Save Learning Module
Submit Learning Module
page1
page1
To calculate the sample mean, first find the sum of all the values:
$\sum x_i$
Edit
Radiogroup
1 . What is the sum?
42
37
64
Other

A holistic student view

- Multiple Data Sources
  - Assessment Data
  - Big 5
  - Statistics Anxiety
  - Free Response
  - Help Forum

Thank You

Acknowledgments

https://lambslab.nd.edu/

Thank you

Questions?

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