Using R and Shiny to Analyze National Assessment Data

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Agenda

1. Context
2. Statement of problem
3. Demo R Package - EdSurvey
4. Demo Shiny App - interactive NCES Results Display (iNRD)
Context - NCES and NAEP
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The National Center for Education Statistics (NCES) is the primary federal entity for collecting and analyzing data related to education in the U.S. and other nations.

The National Assessment of Educational Progress (NAEP) is the largest nationally representative and continuing assessment of what America's students know and can do in various subject areas.

Analyzing NAEP data for students achievement involves:

- Using plausible values to account for uncertainty in the estimates of student test scores; and
- Employing special methods (e.g., jackknife) that account for the NAEP complex sampling design.
Statement of Problem
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1. Cost: requires specialized statistical software
2. Complexity:
   - survey data size can be unwieldy on some machines
   - custom code required to perform analyses
3. Access Limitations: impediments to downloading and reading-in data
4. Inefficiency: cognitive burden creating and reproducing analyses
5. Software Fatigue: data downloading, processing, manipulation and analysis all done in different software
Statement of Problem

Analyzing NCES data is too costly, complex, inaccessible, and burdensome for researchers.
What is EdSurvey?

An R statistical package that gives users functions to connect seamlessly with NCES data to *perform analyses that take into account complex sample survey design and the use of plausible values*. 
Why EdSurvey?

1. **One-stop shop** for data downloading, processing, manipulation and analysis of survey data.

2. **Automated**: Weights and complex sampling design calculations are automated following standard NCES methodology.

3. **Simple**: e.g., a regression with 90 replicate weights requires only a few lines of code.

4. **Flexible**: You can use functions that rely on EdSurvey methods or get the data and use traditional R.

5. **Minimizes memory footprint** by only reading in required data.
One-stop Shop for NCES Survey Analysis

1. Understand the data

2. Clean and manipulate data  
   in EdSurvey

2. Extract and manipulate data  
   in R

3. Run analyses
One-stop Shop for NCES Survey Analysis

1. Understand the data
   - Explore: explore the codebook, see the variables with plausible values, see weights.
   - Search: search variables.
   - Expand: see variable levels, tabulate response percentages, see assessment scores by response category, summarize continuous variables.

   in EdSurvey    in R

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   - Search: search variables.
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2. Clean and manipulate data with built-in subset and recode features.
2. Extract and manipulate data as a data frame (for experienced R users.)

3. Run analyses such as regression analysis, logit analysis, mixed models, show gaps, calculate achievement levels, correlate variables, calculate percentiles.
Demo - EdSurvey
Installing the EdSurvey Package

# to install the package
install.packages("EdSurvey")

# to load the package
library(EdSurvey)
Data Processing
Data Processing

- First, read in the data

```r
sdf <- readNAEP(system.file("extdata/data", "M36NT2PM.dat", package = "NAEP"))
```
Meet Your Data - print

print()

- Print returns detailed data file information:

```
print(sdf)
```

```r
## edsurvey.data.frame for 2005 NAEP (Mathematics) in USA
##
## Dimensions: 17606 rows and 302 columns.
##
## There are 1 full sample weight(s) in this edsurvey.data.frame
##  'origwt' with 62 JK replicate weights (the default).
##
## There are 6 subject scale(s) or subscale(s) in this edsurvey.data.frame
##  'num_oper' subject scale or subscale with 5 plausible values.
##  'measurement' subject scale or subscale with 5 plausible values.
##  'geometry' subject scale or subscale with 5 plausible values.
##  'data_anal_prob' subject scale or subscale with 5 plausible values.
##  'algebra' subject scale or subscale with 5 plausible values.
##  'composite' subject scale or subscale with 5 plausible values (the default).
##
## Omitted Levels: 'Multiple', 'NA', 'Omitted'
```
Data Exploration and Cross Tabulation

- Summary table of NAEP composite mathematics performance scale scores (*composite*) of 8th grade students by two student factors:
  - `dsex`: gender
  - `b017451`: frequency of talk about studies at home

```r
es1 <- edsurveyTable(composite ~ dsex + b017451, data = sdf)
```

<table>
<thead>
<tr>
<th>dsex</th>
<th>b017451</th>
<th>N</th>
<th>WTD_N</th>
<th>PCT</th>
<th>SE(PCT)</th>
<th>MEAN</th>
<th>SE(MEAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Never or hardly ever</td>
<td>2350</td>
<td>2434.844</td>
<td>29.00978</td>
<td>0.6959418</td>
<td>270.8243</td>
<td>1.057078</td>
</tr>
<tr>
<td>Male</td>
<td>Once every few weeks</td>
<td>1603</td>
<td>1638.745</td>
<td>19.52472</td>
<td>0.5020657</td>
<td>275.0807</td>
<td>1.305922</td>
</tr>
<tr>
<td>Male</td>
<td>About once a week</td>
<td>1384</td>
<td>1423.312</td>
<td>16.95795</td>
<td>0.5057265</td>
<td>281.5612</td>
<td>1.409587</td>
</tr>
<tr>
<td>Male</td>
<td>2 or 3 times a week</td>
<td>1535</td>
<td>1563.393</td>
<td>18.62694</td>
<td>0.4811497</td>
<td>284.9066</td>
<td>1.546072</td>
</tr>
<tr>
<td>Male</td>
<td>Every day</td>
<td>1291</td>
<td>1332.890</td>
<td>15.88062</td>
<td>0.5872731</td>
<td>277.2597</td>
<td>1.795784</td>
</tr>
<tr>
<td>Female</td>
<td>Never or hardly ever</td>
<td>1487</td>
<td>1517.609</td>
<td>18.20203</td>
<td>0.5078805</td>
<td>266.7897</td>
<td>1.519020</td>
</tr>
</tbody>
</table>
Linear Regression

- fits a linear model formula using sampling weights and variance estimates:
  - **dsex**: gender
  - **b017451**: frequency of talk about studies at home

```r
lm1 <- lm.sdf(composite ~ dsex + b017451, 
               weightVar = 'origwt', data = sdf) 
summary(lm1)
```

```
##
## Formula: composite ~ dsex + b017451
##
## jrrIMax: 1
## Weight variable: 'origwt'
## Variance method: jackknife
## JK replicates: 62
## full data n: 17606
## n used: 16331
##
## Coefficients:
##                coef        se         t    dof              Pr(>|t|)
## (Intercept)  270.41112   1.02443 263.96149 54.670 < 0.00000000000000022 ***
```

NAEP DATA TRAINING WORKSHOP | NAEP-Research.airprojects.org
EdSurvey Calls Network Connection

Small Memory Footprint

Step 1
Original data on network drive

Step 2
Read in relevant rows and columns

Step 3
Memory is emptied after processing

UseR call:

> lm(composite ~ dsex)

R processes the data

Regression results
Extensive Function Library

- Correlations
- Proportion meeting expectations
- Regression
- Logit/probit
- Quantile regression
- Percentiles
- Mixed models
- Gap trend analysis
Learning EdSurvey

There are many ways to learn about how to use EdSurvey:

- Frequently offered workshops
- Reading vignettes on the EdSurvey Website (https://www.air.org/page/edsurvey-installation-and-use)
- Accessing vignettes via the package (requires internet)

```r
vignette("introduction", package="EdSurvey")
```

- R help

```r
help(package = "EdSurvey")
```
iNRD
iNRD

- A Shiny exploratory tool that visualizes results from one of the NCES data -National Assessment of Educational Progress (NAEP)- across year
- The iNRD is built using the R statistical software and it features an interactive interface with dropdowns, checkboxes and slider bars for ease of use
- Users can explore NAEP results and create customized plots including charts and maps that display NAEP national, state, and TUDA performances across multiple years, and broken down across a variety of student groups. Users can also download and save their plots to the png, pdf, or svg format.
• Some current NCES data visualization tools are cumbersome
  ○ In NAEP Data Explorer and International Data Explorer, a user has to follow certain procedure to achieve a goal. Any mistake in a intermediate step will mess up the whole process, and the user has to go back to the beginning and restart the analysis.
  ○ Does not support sophisticated data exploration
Trend in fourth-grade NAEP mathematics average scores by Gender

Interactive NAEP Results Display Tool

About Interactive NAEP Results Display

The Interactive NAEP Results Display (INRD) is an exploratory tool that visualizes NAEP mathematics and reading results from 1990 to 2017. The tool is built using the R statistical software and it features an interactive interface with dropdowns, checkboxes and slider bars for ease of use. Users can explore NAEP results and create customized plots including charts and maps that display NAEP national, state, and TUDA performances across multiple years, and broken down across a variety of student groups. Users can also download and save their plots to the png, pdf, or svg format.

Please cite all INRD plots as:

Difference Between EdSurvey

Another tool for research involving NAEP data is the EdSurvey R package, which gives users functions to connect seamlessly with NAEP data sets and to perform analyses that account for both complex sample survey design and the use of plausible values. Although the focus of the EdSurvey R package is for in-depth analyses of full NAEP data sets, INRD features critical demographic variables and groups in visual displays accessible to a wide audience - with or without statistical expertise.

NOTE: This version of INRD is a preliminary version, and is still undergoing active development. We welcome your feedback! Please contact us at EdSurvey.help@air.org with questions, comments, and other inquiries.

Explore Plot Options

- NAEP Line Plots
- NAEP Achievement Level Plots
- NAEP Gap Plots
- NAEP State Comparison Plots
Virginia fourth-grade NAEP mathematics achievement levels by race (black)

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Explore Plot Options

[Images of different plot options]

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NAEP Gap Plots
NAEP State Comparison Plots
Percent of Fourth-grade students at or above Proficient in Reading by IEP status (Y)