Using EdSurvey for Trend Analysis

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In large-scale educational studies, such as the National Assessment of Educational Progress (NAEP), the Trends in International Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA), trend analysis often is employed to study the change across time with respect to a statistic (e.g., mean scores, achievement levels/benchmarks, percentages, percentiles, and student group percentages) in a group selected to represent a larger population.

In this vignette, we will show you how to manipulate data to conduct trend analysis. We recommend the following workflow, which we cover point by point:

- Download and load the data into R.
- Rename variables for consistency across datasets.
- Create an `edsurvey.data.frame.list` with all the datafiles in it.
- Recode the variables as necessary.
- Run your analysis.

We will run two types of analyses: a comparison of a student group across years and a comparison of the gap in student groups across years.

For illustration purposes we use the TIMSS 2007, 2011, and 2015 U.S. datasets for fourth-grade students.

Download and Load the Data Into R

Before you can analyze the data, you will need to download and load in the TIMSS datasets. This can be done using the `EdSurvey`'s `downloadTIMSS` function, and data will be downloaded to a directory that the user specifies. That directory will depend on your operating system, so we show how to download and load the data in separate sections for Windows and Mac OS.

Please note that the function works only for TIMSS 2003, 2007, 2011, and 2015 data. One also can manually download desirable data from the IEA Data Repository or timssandpirls.bc.edu.

##Download TIMSS data for Windows

You must first load `EdSurvey`.

```
library(EdSurvey)
```

Then download the data to folders in the `C:` directory. The following command puts the 2007, 2011, and 2015 data in folders named `C:\TIMSS2007`, `C:\TIMSS2011`, and `C:\TIMSS2015`, respectively.

```
downloadTIMSS(years = c(2007, 2011, 2015), root = "C:/", cache = FALSE)
```

Note: The slash must be a forward slash because of a requirement of `R`.

You can then read in the TIMSS U.S. data from the directories using `EdSurvey`'s `readTIMSS` function, and assign them names, `TIMMS07`, `TIMSS11`, and `TIMSS15`.

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```
TIMSS07<- readTIMSS(paste0(edsurveyHome, "TIMSS/2007"), countries = c("usa"), gradeLvl = "4")
TIMSS11<- readTIMSS(paste0(edsurveyHome, "TIMSS/2011"), countries = c("usa"), gradeLvl = "4")
TIMSS15<- readTIMSS(paste0(edsurveyHome, "TIMSS/2015"), countries = c("usa"), gradeLvl = "4")
```

This operation takes several minutes to run the first time and then runs nearly instantly after that. Subsequent calls to `readTIMSS` are stored on the user's drive for easy access.

##Download TIMSS Data for Mac OS

You must first load `EdSurvey`.

```
library(EdSurvey)
```

Then download the data to folders in a new directory in your home folder named `data`. The following command puts the 2007, 2011, and 2015 data in folders named `~/EdSurveyData/TIMSS2007`, `~/EdSurveyData/TIMSS2011`, and `~/EdSurveyData/TIMSS2015`, respectively.

```
dir.create("~/EdSurveyData/")
downloadTIMSS(years=c(2007, 2011, 2015), root = "~/EdSurveyData/", cache = FALSE)
```

Note: If it does not already exist, this will create a folder named /EdSurveyData/ in your home folder.

You can then read in the TIMSS U.S. data from the directories using `EdSurvey`'s `readTIMSS` function and assign them names: `TIMMS07`, `TIMSS11`, and `TIMSS15`.

```
TIMSS07<- readTIMSS("~/EdSurveyData/TIMSS2007", countries = c("usa"), gradeLvl = "4")
TIMSS11<- readTIMSS("~/EdSurveyData/TIMSS2011", countries = c("usa"), gradeLvl = "4")
TIMSS15<- readTIMSS("~/EdSurveyData/TIMSS2015", countries = c("usa"), gradeLvl = "4")
```

This operation takes several minutes to run the first time and then runs nearly instantly after that. Subsequent calls to `readTIMSS` are stored on the user's drive for easy access.

Rename Variables for Consistency Across Datasets

For one of our examples, we will use the *Speak Language of Test at Home* variable, which was named "as4golan" in TIMSS 2007 but "asbg03" in TIMSS 2011 and 2015. We can use the `rename.sdf` function to make the variable name consistent across years.

The following code renames "as4golan" in TIMSS 2007 as "asbg03" and saves the revised data to the `TIMSS07` dataset.

```
TIMSS07 <- rename.sdf(TIMSS07, "as4golan", "asbg03")
```

This process can be done for any variable with names that vary across years. Note that modifying response scales differently for different years of data is not ideal because the perception of the items may change when the response scale changes. But if you want to do that, the best time to do it is before the results are merged.

You can now check if the response scale is uniform across years by combining all the datasets together into an `edsurvey.data.frame.list` and checking the response scales with `searchSDF`.

```
allData <- edsurvey.data.frame.list(list(TIMSS15, TIMSS11, TIMSS07))
searchSDF(string="asbg03", data=allData, levels = TRUE)
```

```
## [[1]]
## Variable: asbg03
## Label: GEN\OFTEN SPEAK <LANG OF TEST> AT HOME
## Levels (Lowest level first):
##      1. ALWAYS
```

```
##      2. ALMOST ALWAYS
##      3. SOMETIMES
##      4. NEVER
##      9. OMITTED OR INVALID
##
## [[2]]
## Variable: asbg03
## Label: GEN\OFTEN SPEAK <LANG OF TEST> AT HOME
## Levels (Lowest level first):
##      1. ALWAYS OR ALMOST ALWAYS
##      2. SOMETIMES
##      3. NEVER
##      9. OMITTED OR INVALID
##
## [[3]]
## Variable: asbg03
## Label: GEN\OFTEN SPEAK <LANGUA OF TEST> AT HOME
## Levels (Lowest level first):
##      1. ALWAYS
##      2. ALMOST ALWAYS
##      3. SOMETIMES
##      4. NEVER
##      9. OMITTED
```

Because we will conduct a gap analysis across years in this vignette, we recode the "asbg03" to condense the response scales on the `TIMSS07` and `TIMSS15` datasets.

```
TIMSS07 <- recode.sdf(TIMSS07,
                      recode = list(asbg03 = list(from = c("ALWAYS","ALMOST ALWAYS"),
                                                  to = "ALWAYS OR ALMOST ALWAYS")))

# TIMSS11 is already coded in this way, so no recode is needed.

TIMSS15 <- recode.sdf(TIMSS15,
                      recode = list(asbg03 = list(from = c("ALWAYS", "ALMOST ALWAYS"),
                                                  to = "ALWAYS OR ALMOST ALWAYS")))
```

Create an edsurvey.data.frame.list With All the Datafiles in It

For trend analysis, use the `edsurvey.data.frame.list` function to combine a series of data from each year into an `edsurvey.data.frame.list` and assign a label to each year. The `edsurvey.data.frame.list` allows the user to compare the results across the datasets.

If you do not supply a label, the function will automatically add the year of the assessment to the output. We think the output is cleaner with these longer labels.

The following code combines updated TIMSS datasets into a new `edsurvey.data.frame.list` called `trendCleaned`.

```
trendCleaned <- edsurvey.data.frame.list(list(TIMSS15, TIMSS11, TIMSS07),
                                         labels=c("TIMSS 2015", "TIMSS 2011", "TIMSS 2007"))
```

Note: The `edsurvey.data.frame.list` also can be used to combine geographic data, if one wants to perform analysis across jurisdictions or countries (e.g., compare a gender gap across countries). For more information about that, type `?EdSurvey::gap` in the R window to see the help section.

Recode the Variables as Necessary

Here we recode the levels to "Frequently" or "Infrequently" to simplify the response scale.

```
trendCleaned <- recode.sdf(trendCleaned,
                           recode = list(asbg03 = list(from = c("ALWAYS OR ALMOST ALWAYS"),
                                                       to = "FREQUENTLY"),
                                         asbg03 = list(from = c("SOMETIMES","NEVER"),
                                                       to = "INFREQUENTLY")))
```

Now, in the `edsurvey.data.frame.list` `trendCleaned`, the *Speak Language of Test at Home* variable is called `asbg03` with two levels: `FREQUENTLY` and `INFREQUENTLY`. Next, we will use `trendCleaned` for further analysis.

Run Your Analysis

We run two analyses here. The first analysis looks at the change in assessment scores on TIMSS Grade 4 on the mathematics subject scale (`mmat`). The second looks at the change in the gap in this score between students based on *Speak Language of Test at Home* across years.

Raw Mathematics Subject Scale Trend

The following example shows comparisons of students' TIMSS mathematics achievement across years using `EdSurvey`'s `gap` function. We will use the TIMSS mathematics subject scale scores, 'mmat', as the dependent variable. Users can select a subscale or another subject scale if they prefer. Use `showPlausibleValues` or print the `edsurvey.data.frame` (e.g., `print(TIMSS15)`) to determine which available scales can be used in each data set.

```
gapResult <- gap(variable = 'mmat', data = trendCleaned)
```

The full results can be seen by typing the following:

```
gapResult
```

```
## gapList
## Call: gap(variable = "mmat", data = trendCleaned)
##
## labels:
##  group definition
##      A    default
##      B       NULL
##
## percentage:
##      labels pctA pctAse diffAA covAA diffAAse diffAApValue dofAA
##  TIMSS 2015  100      0     NA    NA       NA           NA    NA
##  TIMSS 2011  100      0      0     0        0           NA     0
##  TIMSS 2007  100      0      0     0        0           NA     0
##
## results:
##      labels estimateA estimateAse    diffAA covAA diffAAse diffAApValue
##  TIMSS 2015  539.1556    2.231920        NA    NA       NA           NA
##  TIMSS 2011  540.6493    1.816651 -1.493707     0 2.877792  0.604278893
##  TIMSS 2007  529.0091    2.448365 10.146526     0 3.312999  0.002514764
##     dofAA sameSurvey
```

```
##        NA         NA
##  208.5829      FALSE
##  188.5824      FALSE
```

Such output is very verbose. One simplification is to view the results in a spreadsheet-style data viewer in R or RStudio, using the `View` function.

```
View(gapResult$results)
```

Another is to look at just the columns that are of interest.

```
gapResult$results[,c("labels", "estimateA", "estimateAse", "diffAA", "diffAAse",
                     "dofAA", "diffAApValue")]
```

```
##       labels estimateA estimateAse    diffAA diffAAse    dofAA
## 1 TIMSS 2015  539.1556    2.231920        NA       NA       NA
## 2 TIMSS 2011  540.6493    1.816651 -1.493707 2.877792 208.5829
## 3 TIMSS 2007  529.0091    2.448365 10.146526 3.312999 188.5824
##   diffAApValue
## 1           NA
## 2  0.604278893
## 3  0.002514764
```

In `gapResult$results`:

- Students' TIMSS mathematics average score (`estimateA`) in 2015 is `539.1556`, with a standard error (`estimateAse`) of `2.231920`.
- The difference in average math scores between the `TIMSS15` and `TIMSS11` (`diffAA`) is `-1.493707`, with a standard error (`diffAAse`) of `2.877792`, degrees of freedom (`dofAA`) of `208.5829` and a p-value (`diffAApValue`) of `0.604278893`.
- The difference in average math scores between the `TIMSS15` and `TIMSS07` is `10.146526`, with a standard error of `3.312999`, degrees of freedom of `188.5824`, and a p-value of `0.002514764`.

By default, this example treats the first data frame (i.e., TIMSS15) as the reference data. If we want to change the reference to another data, we can use the `referenceDataIndex` argument. For example, setting `referenceDataIndex` argument = 2 will make the second data frame as the reference data.

```
gapResult2 <- gap(variable = 'mmat', data = trendCleaned, referenceDataIndex = 2)
gapResult2$results[,c("labels", "estimateA", "estimateAse", "diffAA", "diffAAse",
                      "dofAA", "diffAApValue")]
```

```
##       labels estimateA estimateAse    diffAA diffAAse    dofAA
## 1 TIMSS 2015  539.1556    2.231920  1.493707 2.877792 208.5829
## 2 TIMSS 2011  540.6493    1.816651        NA       NA       NA
## 3 TIMSS 2007  529.0091    2.448365 11.640233 3.048723 173.4369
##   diffAApValue
## 1 0.6042788933
## 2           NA
## 3 0.0001870115
```

##Comparison of Two Student Groups Across Years

This example demonstrates how to compare a gap with respect to TIMSS mathematics subject scale scores across years. Recall that in the `trendCleaned` data frame list, the labels of `asbg03` were recoded into two levels across three years: `FREQUENTLY` and `INFREQUENTLY`. The following code shows how to run the comparison between these two levels.

```
gapResult3 <- gap(variable = 'mmat', data = trendCleaned,
                  groupA = asbg03 %in% "FREQUENTLY", groupB = asbg03 %in% "INFREQUENTLY")
```

First, let's look just at the results within years.

```
gapResult3$results[,c("labels", "estimateA", "estimateAse",
                      "estimateB", "estimateBse", "diffAB")]
```

```
##       labels estimateA estimateAse estimateB estimateBse   diffAB
## 1 TIMSS 2015  544.8667    2.202195  521.5521    4.223168 23.31467
## 2 TIMSS 2011  545.8112    1.772656  512.0232    3.449441 33.78801
## 3 TIMSS 2007  535.1269    2.257466  490.4574    4.293103 44.66953
```

The students who frequently spoke the language of the test obtained average mathematics scores (`estimateA`) of `544.8667` in TIMSS 2015 with a standard error (`estimateAse`) of `2.202195`. Whereas, those `INFREQUENTLY` students had average mathematics scores (`estimateB`) of `521.5521` in 2015 with a standard error (`estimateBse`) of `4.223168`. The difference between these two groups in 2015 TIMSS average mathematics scores (`diffAB`) is `23.31467`.

More statistics about the difference also could be of interest.

```
gapResult3$results[,c("labels", "diffAB", "diffABse", "dofAB", "diffABpValue")]
```

```
##       labels   diffAB diffABse     dofAB diffABpValue
## 1 TIMSS 2015 23.31467 3.982428  55.72187  2.65813e-07
## 2 TIMSS 2011 33.78801 3.365551 129.40204  0.00000e+00
## 3 TIMSS 2007 44.66953 3.822583  77.80704  0.00000e+00
```

The standard error of the difference between students who frequently spoke the language of the test at home and those who did not (`diffABse`) is `3.982428`. The degrees of freedom (`dofAB`) for the difference is `55.72187`, and the p-value (`diffABpValue`) of the difference is `2.65813e-07`.

Now, looking across years just at students who frequently spoke the language of the test at home.

```
gapResult3$results[,c("labels", "estimateA", "diffAA", "diffAAse",
                      "dofAA", "diffAApValue")]
```

```
##       labels estimateA     diffAA diffAAse    dofAA diffAApValue
## 1 TIMSS 2015  544.8667         NA       NA       NA           NA
## 2 TIMSS 2011  545.8112 -0.9444945 2.827008 246.5231  0.738590479
## 3 TIMSS 2007  535.1269  9.7398613 3.153699 187.2563  0.002318604
```

The average mathematics scores between the `TIMSS15` and `TIMSS11` (`diffAA`) is `-0.9444945` with a standard error (`diffAAse`) of `2.827008`. The degrees of freedom (`dofAA`) is `246.5231` and a p-value (`diffAApValue`) of `0.738590479`.

A similar comparison could be made for students who infrequently spoke the language of the test at home using the `B` variables.

Now, look at the gap between students who spoke the language of the test at home frequently and infrequently.

```
gapResult3$results[,c("labels", "diffAB", "diffABAB", "diffABABse",
                      "dofABAB", "diffABABpValue")]
```

```
##       labels   diffAB  diffABAB diffABABse  dofABAB diffABABpValue
## 1 TIMSS 2015 23.31467        NA         NA       NA             NA
## 2 TIMSS 2011 33.78801 -10.47334   5.214083 134.2496   0.0465785191
## 3 TIMSS 2007 44.66953 -21.35487   5.520134 127.9291   0.0001734967
```

The gap of these two groups of students in average mathematics scores between `TIMSS15` and `TIMSS11` (`diffABAB`) is `-10.47334`, with a standard error (`diffABABse`) of `5.214083`. The degrees of freedom (`dofABAB`) is `134.2496`, and the p-value (`diffABABpValue`) is `0.0465785191`.

In this vignette, we show examples of trend analysis with respect to mean scores (achievement scores). The

`EdSurvey`'s `gap` function also allows analyses with respect to achievement levels (benchmarks), percentiles, and percentages. Please see the Gap Analysis section in the `EdSurvey` vignette for examples.