# Project Report

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## Introduction

Our client, Catherine Ritz, a professor at Boston University's Department of Education, administered a survey pilot, completed by 86 individuals. Her goal was to investigate how foreign language teachers felt about the TELL Framework, a set of suggested characteristics a model foreign language teachers should have. In particular, she was interested in seeing if the would differ by the teacher's demographic or the language of teaching. Her survey included 18 questions regarding the teacher's backgrounds, and 200 questions regarding the TELL Framework. In particular, she took the listed characteristics from four of the major domains, and asked two questions about each one: if the teacher thought it was important for model teaching, and if the teacher was confident in applying it. At our intake meeting, our client discussed improving the survey design for her final study. In particular, she was looking for a way to reduce the number of survey questions.

Our purpose for our client in this project: 1. A lot of people don't answer the survey because it's long. Can we reduce the number of questions? 2. Is the survey currently answering the research questions?

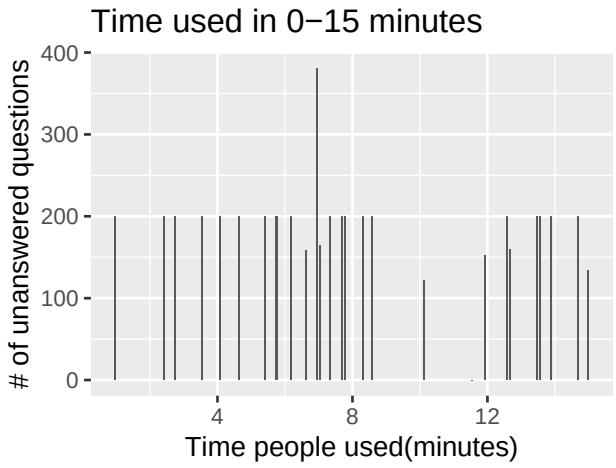
## EDA & Conerns

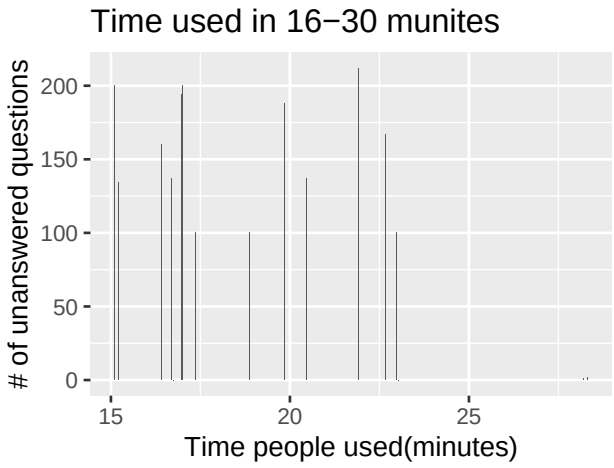
### Data Structure

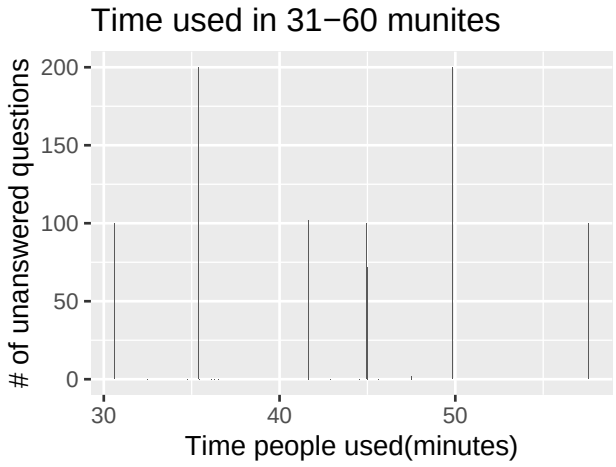
We are provided the data in an excel file with 6 spreadsheets including one sheet of notes, one sheet of personal information and 4 sheets of Teacher Effectiveness for Language Learning (TELL) framework survey questions. The dataset of personal information contains questions regarding respondents' teaching language and education background. The dataset of Teacher Effectiveness for Language Learning (TELL) framework survey contains around 200 questions asking about respondents' attitudes of contribution and confidence towards each practice in the framework. There are 4 domains of Teacher Effectiveness for Language Learning (TELL) survey questions: planning, learning experience, learning tools, and performance & feedback. Each domain contains several subdomains and each subdomain contains a different number of questions. For this project, we focus on reducing the number of questions in the dataset of Teacher Effectiveness for Language Learning (TELL) framework survey.

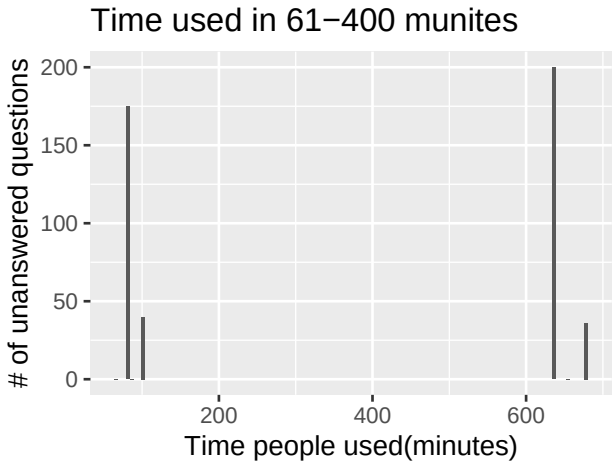
### EDA

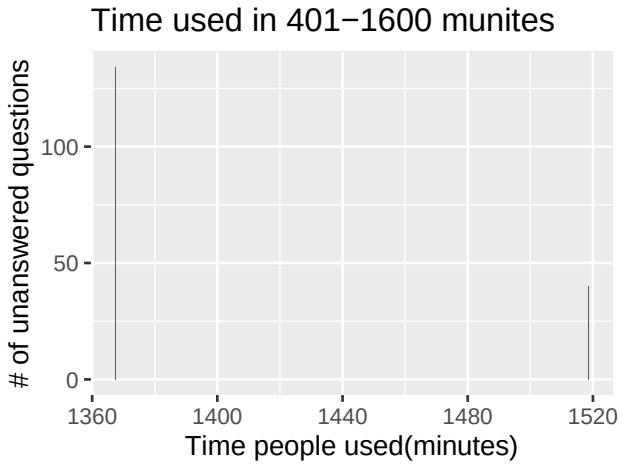
We conduct a basic Exploratory Data Analysis (EDA) for this project. Firstly, We focus on the time for respondents to complete this survey.




## Data Cleaning

## Concerns

We come up with several concerns after the initial EDA. Firstly, the observations we can use in the analysis are very limited since there are many N/A in the dataset. Secondly, some respondents seem like choosing the same answer through the whole survey and if we identify these answers as non-valid, then our sample size would become even smaller. With this limited sample size, the accuracy and reference of results from our subsequent analysis could be affected.

Table 1: TABLE A: 'Planning' Subdomain Summary

| Section | Questions | P-Value | CFI | TLI |
|---|---|---|---|---|
| PL1 | PL1a,PL1b,PL1c,PL1d,PL1f | 0.887 | 1 | 1.103 |
| PL2 | PL2a,PL2b,PL2c | 0.292 | 0.995 | 0.986 |
| PL3 | PL3a,PL3d,PL3e | 0.902 | 1 | 1.071 |
| PL4 | PL4a,PL4b,PL4c | 0.051 | 0.944 | 0.832 |
| PL5 | PL5a,PL5b,PL5c,PL5d | 0.261 | 0.981 | 0.943 |
| PL6 | PL6a,PL6b,PL6c | 0.283 | 0.991 | 0.974 |
| PL7 | PL7a,PL7b,PL7c | 0.903 | 1 | 1.091 |
| PL8 | PL8a,PL8b,PL8c | 0.301 | 0.998 | 0.994 |

### Methods

We will use Confirmatory Factor Analysis (CFA) to reduce the survey questions number. CFA is a special form of factor analysis and mostly used in social science research. It is used to check whether measures of a construct are consistent with a researcher's understanding of the nature of that construct.
Here we will use CFA to see if there are survey questions equivalent to each other so we can reduce those repeated questions. We will analysis each subdomain separately and will only consider the problems regarding confidence or not. Within each subdomain, there will be several questions and our null hypothesis is that all survey questions are identical to each other. Then our alternative hypothesis is that the questions are not all equal.
We will focus on the p value result we have from CFA and we will take a p value larger than 0.05 to reject our null hypothesis. When we are not able to reject our null hypothesis, we will look at our factor loading to check the correlations between questions. Then we will fit new model by dropping question with lowest factor loading and see if we will reject our null hypothesis now. We will keep doing this until we have a subdomain with an acceptable p value, which gives us a set of survey questions are not identical to each other.

## Analysis

### "Planning" Subdomain Analysis

```
PLTable <- rbind(PL1table,PL2table,PL3table,PL4table,PL5table,PL6table,PL7table,PL8table)
colnames(PLTable) <- c("Section","Questions","P-Value","CFI","TLI")
rownames(PLTable) <- NULL
kable(PLTable,digits=3,booktabs=T,caption="TABLE A: 'Planning' Subdomain Summary")
```

Summary statistics for the subdomains of PL1 are shown in Table A. Questions were removed based on our protocol, and the remaining questions are shown in the "Questions" table. Questions PL1e, PL1g, PL3b,PL3c, PL6d, and PL8d were removed. All additional questions were found to not fit well within the model, and may need to be treated separately. The models meet the gold standard of a Comparative Fit Index (CFI) of 0.90, indicating that there is not a major discrepancy between the hypothetical models and the data. The Tucker-Lewis Index (TLI) for each model are also close or lower to 1, supporting that the data and models seem to be close. The P-values for each of the model all are relatively high, indicating that they most likely follow the null hypothesis. Effectively, this means that the questions within the model can be grouped into their subdomain. PL4 may be the only exception, since it has a P-value close to 0.051. However, the CFI and TLI of the model remain high, so it may be correct to use it as one model.

### Learning Tool Domain Analysis

For Learning Tools table in TELL Statements, we numeric character answers of LT 1a~5c Confidence, and NA values stay as same as NA that will not count in. First, I made CFA models for each subdomain (ex: LT1

has 3 variables: LT1a_Confidence, LT1b_Confidence, LT1c_Confidence).Then we have an available P-value for each subdomain and we find factor loadings of each variables in each subdomain. Third, we compare P-value of each subdomain to 0.05, if P-value $> 0.05$, our null hypothesis retained, and we do not need to make any further change on that subdomain; if P-value $< 0.05$, it means our null hypothesis is rejected, and we need to remodel by droping the variable with lowest factor loadings in that subdomain and check its P-value again. Following are detailed results: # First subdomain:

```
## lavaan 0.6-5 ended normally after 12 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          6
##   Number of equality constraints                     1
##   Row rank of the constraints matrix                 1
##
##                                                   Used       Total
##   Number of observations                            27          84
##
## Model Test User Model:
##
##   Test statistic                                 0.109
##   Degrees of freedom                                 1
##   P-value (Chi-square)                           0.741
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lt1 =~
##     LT1_Cnfdn (aa)    0.384    0.165    2.331    0.020    0.384    0.488
##     LT1b_Cnfd (aa)    0.384    0.165    2.331    0.020    0.384    0.472
##     LT1c_Cnfd         0.612    0.282    2.167    0.030    0.612    0.722
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .LT1a_Confidenc    0.472    0.168    2.816    0.005    0.472    0.762
##    .LT1b_Confidenc    0.515    0.177    2.914    0.004    0.515    0.777
##    .LT1c_Confidenc    0.344    0.314    1.095    0.273    0.344    0.479
##     lt1               1.000                              1.000    1.000
```

```
##                npar                fmin               chisq
##               5.000               0.002               0.109
##                  df              pvalue      baseline.chisq
##               1.000               0.741               7.404
##         baseline.df     baseline.pvalue                 cfi
##               3.000               0.060               1.000
##                tli                nnfi                 rfi
##               1.607               1.607               0.956
##                nfi                pnfi                 ifi
##               0.985               0.328               1.139
##                rni                logl   unrestricted.logl
```

```
##               1.202             -94.804             -94.750
##                 aic                 bic              ntotal
##             199.609             206.088              27.000
##                bic2               rmsea      rmsea.ci.lower
##             190.555               0.000               0.000
##      rmsea.ci.upper        rmsea.pvalue                 rmr
##               0.355               0.749               0.018
##          rmr_nomean                srmr        srmr_bentler
##               0.018               0.028               0.028
## srmr_bentler_nomean                crmr         crmr_nomean
##               0.028               0.028               0.028
##          srmr_mplus   srmr_mplus_nomean               cn_05
##               0.026               0.026             951.942
##               cn_01                 gfi                agfi
##            1643.449               0.997               0.984
##                pgfi                 mfi                ecvi
##               0.166               1.017               0.374
```

```
##                lhs op             rhs    mi    epc sepc.lv sepc.all
## 10 LT1a_Confidence ~~ LT1c_Confidence 0.109  0.053   0.053    0.133
## 11 LT1b_Confidence ~~ LT1c_Confidence 0.109 -0.053  -0.053   -0.127
##    sepc.nox
## 10    0.133
## 11   -0.127
```

Table 2: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| lt1 | LT1a_Confidence | 0.384 | 0.165 | 2.331 | 0.02 | 0.488 |
| lt1 | LT1b_Confidence | 0.384 | 0.165 | 2.331 | 0.02 | 0.472 |
| lt1 | LT1c_Confidence | 0.612 | 0.282 | 2.167 | 0.03 | 0.722 |

Since p-value of the first subdomain is $0.741 > 0.05$, there is no need to make any change in the first subdomain and we can save all questions.

## Second subdomain

```
## lavaan 0.6-5 ended normally after 12 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          6
##   Number of equality constraints                     1
##   Row rank of the constraints matrix                 1
##
##                                                   Used       Total
##   Number of observations                            28          84
##
## Model Test User Model:
##
##   Test statistic                                 0.003
##   Degrees of freedom                                 1
##   P-value (Chi-square)                           0.953
```

```
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lt2 =~
##     LT2_Cnfdn (aa)    0.443    0.126    3.531    0.000    0.443    0.587
##     LT2b_Cnfd (aa)    0.443    0.126    3.531    0.000    0.443    0.603
##     LT2c_Cnfd         0.776    0.222    3.499    0.000    0.776    0.817
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .LT2a_Confidenc    0.373    0.127    2.930    0.003    0.373    0.655
##    .LT2b_Confidenc    0.345    0.122    2.838    0.005    0.345    0.637
##    .LT2c_Confidenc    0.300    0.270    1.110    0.267    0.300    0.333
##     lt2               1.000                               1.000    1.000
```

```
##                npar                fmin               chisq
##               5.000               0.000               0.003
##                  df              pvalue      baseline.chisq
##               1.000               0.953              15.764
##         baseline.df     baseline.pvalue                 cfi
##               3.000               0.001               1.000
##                 tli                nnfi                 rfi
##               1.234               1.234               0.999
##                 nfi                pnfi                 ifi
##               1.000               0.333               1.067
##                 rni                logl   unrestricted.logl
##               1.078            -93.396             -93.394
##                 aic                 bic              ntotal
##             196.792             203.453              28.000
##                bic2                rmsea      rmsea.ci.lower
##             187.908               0.000               0.000
##      rmsea.ci.upper        rmsea.pvalue                 rmr
##               0.000               0.955               0.003
##          rmr_nomean                srmr        srmr_bentler
##               0.003               0.005               0.005
## srmr_bentler_nomean                crmr         crmr_nomean
##               0.005               0.004               0.004
##          srmr_mplus   srmr_mplus_nomean                cn_05
##               0.005               0.005           31204.347
##               cn_01                 gfi                agfi
##           53894.843               1.000               1.000
##                pgfi                 mfi                ecvi
##               0.167               1.018               0.357
```

```
##                lhs op             rhs    mi    epc sepc.lv sepc.all
## 10 LT2a_Confidence ~~ LT2c_Confidence 0.003 -0.009  -0.009   -0.027
## 11 LT2b_Confidence ~~ LT2c_Confidence 0.003  0.009   0.009    0.028
##    sepc.nox
## 10   -0.027
```

```
## 11    0.028
```

Table 3: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| lt2 | LT2a_Confidence | 0.443 | 0.126 | 3.531 | 0 | 0.587 |
| lt2 | LT2b_Confidence | 0.443 | 0.126 | 3.531 | 0 | 0.603 |
| lt2 | LT2c_Confidence | 0.776 | 0.222 | 3.499 | 0 | 0.817 |

Since p-value of the second subdomain is $0.953 > 0.05$, there is no need to make any change in the second subdomain and we can save all questions.

# Third subdomain

```
## lavaan 0.6-5 ended normally after 15 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          8
##
##                                                   Used       Total
##   Number of observations                            27          84
##
## Model Test User Model:
##
##   Test statistic                                 9.736
##   Degrees of freedom                                 2
##   P-value (Chi-square)                           0.008
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lt3 =~
##     LT3a_Confidenc    0.858    0.158    5.419    0.000    0.858    0.885
##     LT3b_Confidenc    0.724    0.147    4.933    0.000    0.724    0.827
##     LT3c_Confidenc    0.528    0.161    3.273    0.001    0.528    0.604
##     LT3d_Confidenc    0.804    0.200    4.020    0.000    0.804    0.709
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .LT3a_Confidenc    0.204    0.120    1.697    0.090    0.204    0.217
##    .LT3b_Confidenc    0.242    0.102    2.375    0.018    0.242    0.316
##    .LT3c_Confidenc    0.486    0.144    3.376    0.001    0.486    0.635
##    .LT3d_Confidenc    0.638    0.204    3.131    0.002    0.638    0.497
##     lt3               1.000                              1.000    1.000
```

```
##                npar                fmin               chisq
##               8.000               0.180               9.736
```

```
##                  df              pvalue      baseline.chisq
##               2.000               0.008              55.912
##         baseline.df     baseline.pvalue                 cfi
##               6.000               0.000               0.845
##                 tli                nnfi                 rfi
##               0.535               0.535               0.478
##                 nfi                pnfi                 ifi
##               0.826               0.275               0.857
##                 rni                logl   unrestricted.logl
##               0.845            -125.493            -120.625
##                 aic                 bic              ntotal
##             266.987             277.354              27.000
##                bic2               rmsea      rmsea.ci.lower
##             252.501               0.378               0.166
##      rmsea.ci.upper        rmsea.pvalue                 rmr
##               0.630               0.010               0.091
##          rmr_nomean                srmr        srmr_bentler
##               0.091               0.093               0.093
## srmr_bentler_nomean                crmr         crmr_nomean
##               0.093               0.120               0.120
##          srmr_mplus   srmr_mplus_nomean                cn_05
##               0.093               0.093              17.616
##               cn_01                 gfi                 agfi
##              26.542               0.859               0.293
##                pgfi                 mfi                 ecvi
##               0.172               0.867               0.953
```

```
##                lhs op             rhs    mi    epc sepc.lv sepc.all
## 10 LT3a_Confidence ~~ LT3b_Confidence 8.454  0.533   0.533    2.396
## 11 LT3a_Confidence ~~ LT3c_Confidence 3.565 -0.210  -0.210   -0.665
## 12 LT3a_Confidence ~~ LT3d_Confidence 0.290 -0.093  -0.093   -0.258
## 13 LT3b_Confidence ~~ LT3c_Confidence 0.290 -0.052  -0.052   -0.151
## 14 LT3b_Confidence ~~ LT3d_Confidence 3.565 -0.269  -0.269   -0.685
## 15 LT3c_Confidence ~~ LT3d_Confidence 8.454  0.364   0.364    0.654
##    sepc.nox
## 10    2.396
## 11   -0.665
## 12   -0.258
## 13   -0.151
## 14   -0.685
## 15    0.654
```

Table 4: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| lt3 | LT3a_Confidence | 0.858 | 0.158 | 5.419 | 0.000 | 0.885 |
| lt3 | LT3b_Confidence | 0.724 | 0.147 | 4.933 | 0.000 | 0.827 |
| lt3 | LT3c_Confidence | 0.528 | 0.161 | 3.273 | 0.001 | 0.604 |
| lt3 | LT3d_Confidence | 0.804 | 0.200 | 4.020 | 0.000 | 0.709 |

Since p-value of the third subdomain is $0.008 < 0.05$, and question "LT3c_Confidence" has the lowest factor loading 0.604, we drop "LT3_c_Confidence" and then remodel the third subdomain.

```
## lavaan 0.6-5 ended normally after 14 iterations
```

```
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          6
##   Number of equality constraints                     1
##   Row rank of the constraints matrix                 1
##
##                                                   Used       Total
##   Number of observations                            27          84
##
## Model Test User Model:
##
##   Test statistic                                 0.017
##   Degrees of freedom                                 1
##   P-value (Chi-square)                           0.897
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lt3 =~
##     LT3_Cnfdn         0.931    0.164    5.660    0.000    0.931    0.959
##     LT3b_Cnfd (aa)    0.706    0.144    4.892    0.000    0.706    0.802
##     LT3d_Cnfd (aa)    0.706    0.144    4.892    0.000    0.706    0.629
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .LT3a_Confidenc    0.075    0.170    0.442    0.659    0.075    0.080
##    .LT3b_Confidenc    0.276    0.122    2.259    0.024    0.276    0.357
##    .LT3d_Confidenc    0.761    0.228    3.330    0.001    0.761    0.604
##     lt3               1.000                              1.000    1.000
```

```
##                npar                fmin               chisq
##               5.000               0.000               0.017
##                  df              pvalue      baseline.chisq
##               1.000               0.897              36.819
##         baseline.df     baseline.pvalue                 cfi
##               3.000               0.000               1.000
##                 tli                nnfi                 rfi
##               1.087               1.087               0.999
##                 nfi                pnfi                 ifi
##               1.000               0.333               1.027
##                 rni                logl   unrestricted.logl
##               1.029            -95.478             -95.469
##                 aic                 bic              ntotal
##             200.955             207.434              27.000
##                bic2               rmsea      rmsea.ci.lower
##             191.902               0.000               0.000
##      rmsea.ci.upper        rmsea.pvalue                 rmr
##               0.233               0.900               0.014
```

```
##          rmr_nomean               srmr        srmr_bentler
##               0.014              0.012               0.012
## srmr_bentler_nomean               crmr         crmr_nomean
##               0.012              0.007               0.007
##          srmr_mplus  srmr_mplus_nomean               cn_05
##               0.011              0.011            6147.974
##               cn_01                gfi                agfi
##           10617.940              1.000               0.998
##                pgfi                mfi                ecvi
##               0.167              1.018               0.371
```

```
##                lhs op             rhs    mi    epc sepc.lv sepc.all
## 9  LT3a_Confidence ~~ LT3b_Confidence 0.017 -0.025  -0.025   -0.171
## 10 LT3a_Confidence ~~ LT3d_Confidence 0.017  0.025   0.025    0.103
##    sepc.nox
## 9    -0.171
## 10    0.103
```

Table 5: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| lt3 | LT3a_Confidence | 0.931 | 0.164 | 5.660 | 0 | 0.959 |
| lt3 | LT3b_Confidence | 0.706 | 0.144 | 4.892 | 0 | 0.802 |
| lt3 | LT3d_Confidence | 0.706 | 0.144 | 4.892 | 0 | 0.629 |

After we remodel the third subdomain, the p-value of third domain is $0.897 > 0.05$. Then we can save all the remaining questions in the third subdomain ("LT3a_Confidence", "LT3b_Confidence", "LT3d_Confidence").

# Fourth subdomain

```
## lavaan 0.6-5 ended normally after 19 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          6
##   Number of equality constraints                     1
##   Row rank of the constraints matrix                 1
##
##                                                   Used       Total
##   Number of observations                            28          84
##
## Model Test User Model:
##
##   Test statistic                                 0.016
##   Degrees of freedom                                 1
##   P-value (Chi-square)                           0.899
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
```

```
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lt4 =~
##     LT4_Cnfdn         0.370    0.140    2.640    0.008    0.370    0.469
##     LT4b_Cnfd (aa)    1.077    0.150    7.191    0.000    1.077    1.012
##     LT4c_Cnfd (aa)    1.077    0.150    7.191    0.000    1.077    0.886
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .LT4a_Confidenc    0.485    0.129    3.749    0.000    0.485    0.780
##    .LT4b_Confidenc   -0.027    0.095   -0.282    0.778   -0.027   -0.024
##    .LT4c_Confidenc    0.316    0.127    2.486    0.013    0.316    0.214
##     lt4               1.000                              1.000    1.000
```

```
##                npar                fmin               chisq
##               5.000               0.000               0.016
##                  df              pvalue      baseline.chisq
##               1.000               0.899              52.579
##         baseline.df     baseline.pvalue                 cfi
##               3.000               0.000               1.000
##                 tli                nnfi                 rfi
##               1.060               1.060               0.999
##                 nfi                pnfi                 ifi
##               1.000               0.333               1.019
##                 rni                logl   unrestricted.logl
##               1.020            -93.343            -93.335
##                 aic                 bic              ntotal
##             196.686             203.347              28.000
##                bic2                rmsea      rmsea.ci.lower
##             187.802               0.000               0.000
##      rmsea.ci.upper        rmsea.pvalue                 rmr
##               0.225               0.902               0.008
##          rmr_nomean                srmr        srmr_bentler
##               0.008               0.007               0.007
## srmr_bentler_nomean                crmr         crmr_nomean
##               0.007               0.006               0.006
##          srmr_mplus   srmr_mplus_nomean                cn_05
##               0.006               0.006            6648.164
##               cn_01                 gfi                agfi
##           11481.859               1.000               0.998
##                pgfi                 mfi                ecvi
##               0.167               1.018               0.358
```

```
##                lhs op             rhs    mi   epc sepc.lv sepc.all
## 9  LT4a_Confidence ~~ LT4b_Confidence 0.016  0.01    0.01    0.089
## 10 LT4a_Confidence ~~ LT4c_Confidence 0.016 -0.01   -0.01   -0.026
##    sepc.nox
## 9     0.089
## 10   -0.026
```

Table 6: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| lt4 | LT4a_Confidence | 0.370 | 0.14 | 2.640 | 0.008 | 0.469 |
| lt4 | LT4b_Confidence | 1.077 | 0.15 | 7.191 | 0.000 | 1.012 |

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| lt4 | LT4c_Confidence | 1.077 | 0.15 | 7.191 | 0.000 | 0.886 |

Since p-value of the fourth subdomain is $0.899 > 0.05$, there is no need to make any change in the fourth subdomain and we can save all questions.

# Fifth subdomain

```
## lavaan 0.6-5 ended normally after 13 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          6
##   Number of equality constraints                     1
##   Row rank of the constraints matrix                 1
##
##                                                   Used       Total
##   Number of observations                            26          84
##
## Model Test User Model:
##
##   Test statistic                                 0.774
##   Degrees of freedom                                 1
##   P-value (Chi-square)                           0.379
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lt5 =~
##     LT5_Cnfdn (aa)    0.398    0.124    3.205    0.001    0.398    0.618
##     LT5b_Cnfd         0.620    0.186    3.331    0.001    0.620    0.844
##     LT5c_Cnfd (aa)    0.398    0.124    3.205    0.001    0.398    0.532
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .LT5a_Confidenc    0.257    0.101    2.544    0.011    0.257    0.618
##    .LT5b_Confidenc    0.155    0.186    0.832    0.405    0.155    0.287
##    .LT5c_Confidenc    0.402    0.132    3.034    0.002    0.402    0.717
##     lt5               1.000                              1.000    1.000
```

```
##                npar                fmin               chisq
##               5.000               0.015               0.774
##                  df              pvalue      baseline.chisq
##               1.000               0.379              15.415
##         baseline.df     baseline.pvalue                 cfi
##               3.000               0.001               1.000
##                 tli                nnfi                 rfi
```

```
##               1.055               1.055               0.849
##                 nfi                pnfi                 ifi
##               0.950               0.317               1.016
##                 rni                logl   unrestricted.logl
##               1.018            -76.441             -76.054
##                 aic                 bic              ntotal
##             162.882             169.172              26.000
##                bic2                rmsea      rmsea.ci.lower
##             153.653               0.000               0.000
##      rmsea.ci.upper        rmsea.pvalue                 rmr
##               0.494               0.394               0.041
##          rmr_nomean                srmr        srmr_bentler
##               0.041               0.079               0.079
## srmr_bentler_nomean                crmr         crmr_nomean
##               0.079               0.063               0.063
##          srmr_mplus   srmr_mplus_nomean                cn_05
##               0.070               0.070             130.124
##               cn_01                 gfi                 agfi
##             224.020               0.981               0.885
##                pgfi                 mfi                ecvi
##               0.163               1.004               0.414
```

```
##                lhs op             rhs    mi    epc sepc.lv sepc.all
## 9  LT5a_Confidence ~~ LT5b_Confidence 0.762 -0.102  -0.102   -0.512
## 11 LT5b_Confidence ~~ LT5c_Confidence 0.762  0.102   0.102    0.409
##    sepc.nox
## 9    -0.512
## 11    0.409
```

Table 7: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| lt5 | LT5a_Confidence | 0.398 | 0.124 | 3.205 | 0.001 | 0.618 |
| lt5 | LT5b_Confidence | 0.620 | 0.186 | 3.331 | 0.001 | 0.844 |
| lt5 | LT5c_Confidence | 0.398 | 0.124 | 3.205 | 0.001 | 0.532 |

Since p-value of the fifth subdomain is $0.379 > 0.05$, there is no need to make any change in the fifth subdomain and we can save all questions.

## PER & FEEDBACK Domain Analysis

For PER&FEEDBACK table in TELL Statements, I numeric character answers of PF 1a~5c Confidence, and NA values stay as same as NA that will not count in. First, I made CFA models for each subdomain whose variables should greater than 2 (ex: PF1 has 5 variables: PF1a_Confidence, PF1b_Confidence, PF1c_Confidence,PF1d_Confidence and PF1e_Confidence), or the P-value of that model will become NA. And we get an exception in PF table: PF4 only has 2 varaibles, so I combine PF4 with PF5 to one CFA model so that we have an available P-value. Second, we find factor loadings of each variables in each subdomain and record them. Third, we compare P-value of each subdomain to 0.05, if P-value $> 0.05$, our null hypothesis retained, and we do not need to make any further change on that subdomain; if P-value $< 0.05$, it means our null hypothesis is rejected, and we need to remodel by droping the variable with lowest factor loadings in that subdomain and check its P-value again. Following are detailed results
# First subdomain:

```
## lavaan 0.6-5 ended normally after 21 iterations
```

```
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         10
##
##                                                   Used       Total
##   Number of observations                            27          84
##
## Model Test User Model:
##
##   Test statistic                                15.646
##   Degrees of freedom                                 5
##   P-value (Chi-square)                           0.008
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF1 =~
##     PF1a_Confidenc    0.690    0.202    3.421    0.001    0.690    0.609
##     PF1b_Confidenc    0.879    0.168    5.229    0.000    0.879    0.830
##     PF1c_Confidenc    0.828    0.128    6.471    0.000    0.828    0.946
##     PF1d_Confidenc    0.823    0.135    6.110    0.000    0.823    0.915
##     PF1e_Confidenc    0.584    0.178    3.275    0.001    0.584    0.587
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PF1a_Confidenc    0.808    0.228    3.545    0.000    0.808    0.630
##    .PF1b_Confidenc    0.349    0.110    3.160    0.002    0.349    0.311
##    .PF1c_Confidenc    0.080    0.049    1.628    0.104    0.080    0.105
##    .PF1d_Confidenc    0.132    0.057    2.306    0.021    0.132    0.163
##    .PF1e_Confidenc    0.647    0.182    3.559    0.000    0.647    0.655
##     PF1               1.000                              1.000    1.000
```

Table 8: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| PF1 | PF1a_Confidence | 0.690 | 0.202 | 3.421 | 0.001 | 0.609 |
| PF1 | PF1b_Confidence | 0.879 | 0.168 | 5.229 | 0.000 | 0.830 |
| PF1 | PF1c_Confidence | 0.828 | 0.128 | 6.471 | 0.000 | 0.946 |
| PF1 | PF1d_Confidence | 0.823 | 0.135 | 6.110 | 0.000 | 0.915 |
| PF1 | PF1e_Confidence | 0.584 | 0.178 | 3.275 | 0.001 | 0.587 |

Since p-value of first subdomain is $0.008 < 0.05$, and the factor loadings of "PF1e_Confidence" is lowest, thus, we try to drop it from the first subdomain:

```
## lavaan 0.6-5 ended normally after 31 iterations
##
##   Estimator                                         ML
```

```
##   Optimization method                           NLMINB
##   Number of free parameters                          8
##
##                                                   Used       Total
##   Number of observations                            28          84
##
## Model Test User Model:
##
##   Test statistic                                 0.068
##   Degrees of freedom                                 2
##   P-value (Chi-square)                           0.967
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF1 =~
##     PF1a_Confidenc    0.660    0.196    3.360    0.001    0.660    0.593
##     PF1b_Confidenc    0.835    0.173    4.830    0.000    0.835    0.780
##     PF1c_Confidenc    0.796    0.130    6.135    0.000    0.796    0.914
##     PF1d_Confidenc    0.831    0.129    6.432    0.000    0.831    0.940
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PF1a_Confidenc    0.804    0.223    3.601    0.000    0.804    0.649
##    .PF1b_Confidenc    0.449    0.135    3.321    0.001    0.449    0.392
##    .PF1c_Confidenc    0.125    0.061    2.048    0.041    0.125    0.165
##    .PF1d_Confidenc    0.091    0.061    1.498    0.134    0.091    0.116
##     PF1               1.000                              1.000    1.000
```

P-value = $0.967 > 0.05$, thus we do not need to change any more on the first subdomain.

## Second subdomain:

```
## lavaan 0.6-5 ended normally after 18 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         10
##
##                                                   Used       Total
##   Number of observations                            27          84
##
## Model Test User Model:
##
##   Test statistic                                14.489
##   Degrees of freedom                                 5
##   P-value (Chi-square)                           0.013
##
## Parameter Estimates:
```

```
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF2 =~
##     PF2a_Confidenc    0.561    0.172    3.255    0.001    0.561    0.587
##     PF2b_Confidenc    0.948    0.159    5.981    0.000    0.948    0.905
##     PF2c_Confidenc    0.575    0.188    3.060    0.002    0.575    0.558
##     PF2d_Confidenc    0.896    0.151    5.941    0.000    0.896    0.901
##     PF2e_Confidenc    1.016    0.173    5.880    0.000    1.016    0.896
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PF2a_Confidenc    0.599    0.169    3.534    0.000    0.599    0.655
##    .PF2b_Confidenc    0.199    0.083    2.384    0.017    0.199    0.181
##    .PF2c_Confidenc    0.731    0.206    3.554    0.000    0.731    0.689
##    .PF2d_Confidenc    0.185    0.076    2.439    0.015    0.185    0.188
##    .PF2e_Confidenc    0.255    0.101    2.520    0.012    0.255    0.198
##     PF2               1.000                              1.000    1.000
```

Table 9: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| PF2 | PF2a_Confidence | 0.561 | 0.172 | 3.255 | 0.001 | 0.587 |
| PF2 | PF2b_Confidence | 0.948 | 0.159 | 5.981 | 0.000 | 0.905 |
| PF2 | PF2c_Confidence | 0.575 | 0.188 | 3.060 | 0.002 | 0.558 |
| PF2 | PF2d_Confidence | 0.896 | 0.151 | 5.941 | 0.000 | 0.901 |
| PF2 | PF2e_Confidence | 1.016 | 0.173 | 5.880 | 0.000 | 0.896 |

Since p-value of first subdomain is $0.013 < 0.05$, and the factor loadings of "PF2c_Confidence" is lowest, thus, we try to drop it from the second subdomain:

```
## lavaan 0.6-5 ended normally after 18 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          8
##
##                                                   Used       Total
##   Number of observations                            28          84
##
## Model Test User Model:
##
##   Test statistic                                 1.559
##   Degrees of freedom                                 2
##   P-value (Chi-square)                           0.459
##
## Parameter Estimates:
##
##   Information                                 Expected
```

```
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF2 =~
##     PF2a_Confidenc    0.553    0.169    3.275    0.001    0.553    0.583
##     PF2b_Confidenc    0.910    0.158    5.765    0.000    0.910    0.877
##     PF2d_Confidenc    0.884    0.147    6.012    0.000    0.884    0.901
##     PF2e_Confidenc    1.011    0.167    6.057    0.000    1.011    0.905
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PF2a_Confidenc    0.596    0.166    3.588    0.000    0.596    0.660
##    .PF2b_Confidenc    0.248    0.093    2.675    0.007    0.248    0.231
##    .PF2d_Confidenc    0.182    0.077    2.349    0.019    0.182    0.189
##    .PF2e_Confidenc    0.227    0.099    2.280    0.023    0.227    0.181
##     PF2               1.000                              1.000    1.000
```

P-value = $0.459 > 0.05$, thus we can stay here for the second subdomain.

# Third subdomain:

```
## lavaan 0.6-5 ended normally after 15 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         10
##
##                                                   Used       Total
##   Number of observations                            28          84
##
## Model Test User Model:
##
##   Test statistic                                 2.920
##   Degrees of freedom                                 5
##   P-value (Chi-square)                           0.712
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF3 =~
##     PF3a_Confidenc    0.466    0.184    2.533    0.011    0.466    0.485
##     PF3b_Confidenc    0.869    0.173    5.032    0.000    0.869    0.838
##     PF3c_Confidenc    0.628    0.146    4.300    0.000    0.628    0.746
##     PF3d_Confidenc    0.753    0.169    4.468    0.000    0.753    0.767
##     PF3e_Confidenc    0.543    0.171    3.179    0.001    0.543    0.588
##
## Variances:
```

```
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PF3a_Confidenc    0.706    0.199    3.543    0.000    0.706    0.765
##    .PF3b_Confidenc    0.320    0.149    2.153    0.031    0.320    0.298
##    .PF3c_Confidenc    0.315    0.109    2.893    0.004    0.315    0.444
##    .PF3d_Confidenc    0.396    0.143    2.759    0.006    0.396    0.411
##    .PF3e_Confidenc    0.557    0.164    3.396    0.001    0.557    0.654
##     PF3               1.000                              1.000    1.000
```

Table 10: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| PF3 | PF3a_Confidence | 0.466 | 0.184 | 2.533 | 0.011 | 0.485 |
| PF3 | PF3b_Confidence | 0.869 | 0.173 | 5.032 | 0.000 | 0.838 |
| PF3 | PF3c_Confidence | 0.628 | 0.146 | 4.300 | 0.000 | 0.746 |
| PF3 | PF3d_Confidence | 0.753 | 0.169 | 4.468 | 0.000 | 0.767 |
| PF3 | PF3e_Confidence | 0.543 | 0.171 | 3.179 | 0.001 | 0.588 |
| Since p-value > | 0.05, the third su | bdomain | is ok, n | o longer | to remode | l it. |

# Fourth subdomain:

PF4 only has 2 varaibles, so I combine PF4 with PF5 to one CFA model so that we can get an available P-value.

```
## lavaan 0.6-5 ended normally after 22 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         11
##
##                                                   Used       Total
##   Number of observations                            24          84
##
## Model Test User Model:
##
##   Test statistic                                12.824
##   Degrees of freedom                                 4
##   P-value (Chi-square)                           0.012
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF4 =~
##     PF4a_Confidenc    0.754    0.148    5.099    0.000    0.754    0.888
##     PF4b_Confidenc    0.681    0.145    4.699    0.000    0.681    0.835
##   PF5 =~
##     PF5a_Confidenc    0.690    0.173    3.988    0.000    0.690    0.757
##     PF5b_Confidenc    0.632    0.158    4.003    0.000    0.632    0.759
##     PF5c_Confidenc    0.535    0.192    2.782    0.005    0.535    0.567
```

```
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF4 ~~
##     PF5               0.877    0.113    7.732    0.000    0.877    0.877
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PF4a_Confidenc    0.153    0.101    1.511    0.131    0.153    0.212
##    .PF4b_Confidenc    0.201    0.094    2.131    0.033    0.201    0.302
##    .PF5a_Confidenc    0.355    0.143    2.484    0.013    0.355    0.427
##    .PF5b_Confidenc    0.294    0.119    2.470    0.014    0.294    0.424
##    .PF5c_Confidenc    0.603    0.192    3.135    0.002    0.603    0.678
##     PF4               1.000                              1.000    1.000
##     PF5               1.000                              1.000    1.000
```

Table 11: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| PF4 | PF4a_Confidence | 0.754 | 0.148 | 5.099 | 0.000 | 0.888 |
| PF4 | PF4b_Confidence | 0.681 | 0.145 | 4.699 | 0.000 | 0.835 |
| PF5 | PF5a_Confidence | 0.690 | 0.173 | 3.988 | 0.000 | 0.757 |
| PF5 | PF5b_Confidence | 0.632 | 0.158 | 4.003 | 0.000 | 0.759 |
| PF5 | PF5c_Confidence | 0.535 | 0.192 | 2.782 | 0.005 | 0.567 |

Since P-value is $0.012 < 0.05$, and the lowest factor loading is "PF5c_Confidence", thus we try to drop it from the subdomain:

```
## lavaan 0.6-5 ended normally after 21 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          9
##
##                                                   Used       Total
##   Number of observations                            24          84
##
## Model Test User Model:
##
##   Test statistic                                 0.832
##   Degrees of freedom                                 1
##   P-value (Chi-square)                           0.362
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF4 =~
##     PF4a_Confidenc    0.724    0.155    4.671    0.000    0.724    0.851
```

```
##     PF4b_Confidenc    0.710    0.148    4.808    0.000    0.710    0.871
##   PF5 =~
##     PF5a_Confidenc    0.812    0.171    4.742    0.000    0.812    0.890
##     PF5b_Confidenc    0.635    0.160    3.970    0.000    0.635    0.763
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   PF4 ~~
##     PF5               0.755    0.137    5.507    0.000    0.755    0.755
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .PF4a_Confidenc    0.199    0.116    1.720    0.085    0.199    0.275
##    .PF4b_Confidenc    0.160    0.107    1.497    0.134    0.160    0.241
##    .PF5a_Confidenc    0.173    0.157    1.100    0.271    0.173    0.207
##    .PF5b_Confidenc    0.289    0.124    2.342    0.019    0.289    0.418
##     PF4               1.000                              1.000    1.000
##     PF5               1.000                              1.000    1.000
```

P-value is $0.362 > 0.05$, thus no longer remodel this subdomain.

## Learning Experience Domain Analysis

For learning experience table in TELL Statements, we numeric character answers of LE 1a~6d Confidence, and NA values stay as same as NA that will not count in. First, I made CFA models for each subdomain (ex: LE1 has 5 variables: LE1a_Confidence, LE1b_Confidence, LE1c_Confidence,LE1d_Confidence and LE1e_Confidence).Then we have an available P-value for each subdomain and we find factor loadings of each variables in each subdomain. Third, we compare P-value of each subdomain to 0.05, if P-value $> 0.05$, our null hypothesis retained, and we do not need to make any further change on that subdomain; if P-value $< 0.05$, it means our null hypothesis is rejected, and we need to remodel by droping the variable with lowest factor loadings in that subdomain and check its P-value again. Following are detailed results

## First subdomian

```
## lavaan 0.6-5 ended normally after 28 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         10
##
##                                                   Used       Total
##   Number of observations                            29          84
##
## Model Test User Model:
##
##   Test statistic                                 2.594
##   Degrees of freedom                                 5
##   P-value (Chi-square)                           0.762
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
```

```
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   LE1 =~
##     LE1a_Confidenc    1.000
##     LE1b_Confidenc    0.601    0.230    2.619    0.009
##     LE1c_Confidenc    0.837    0.298    2.812    0.005
##     LE1d_Confidenc    0.589    0.236    2.495    0.013
##     LE1e_Confidenc    0.351    0.215    1.632    0.103
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .LE1a_Confidenc    0.690    0.699    0.987    0.324
##    .LE1b_Confidenc    2.142    0.632    3.391    0.001
##    .LE1c_Confidenc    3.173    0.985    3.221    0.001
##    .LE1d_Confidenc    2.411    0.696    3.465    0.001
##    .LE1e_Confidenc    2.590    0.698    3.711    0.000
##     LE1               2.646    1.091    2.424    0.015
```

Table 12: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| LE1 | LE1a_Confidence | 1.000 | 0.000 | NA | NA | 0.891 |
| LE1 | LE1b_Confidence | 0.601 | 0.230 | 2.619 | 0.009 | 0.556 |
| LE1 | LE1c_Confidence | 0.837 | 0.298 | 2.812 | 0.005 | 0.607 |
| LE1 | LE1d_Confidence | 0.589 | 0.236 | 2.495 | 0.013 | 0.525 |
| LE1 | LE1e_Confidence | 0.351 | 0.215 | 1.632 | 0.103 | 0.334 |

The p-value of this subdomian is 0.762, so we will keep all the questions in this subdomian.

## Second Subdomain

```
## lavaan 0.6-5 ended normally after 32 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         12
##
##                                                   Used       Total
##   Number of observations                            28          84
##
## Model Test User Model:
##
##   Test statistic                                18.696
##   Degrees of freedom                                 9
##   P-value (Chi-square)                           0.028
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
```

```
##                    Estimate  Std.Err  z-value  P(>|z|)
##   LE2 =~
##     LE2a_Confidenc    1.000
##     LE2b_Confidenc    1.036    0.486    2.131    0.033
##     LE2c_Confidenc    1.428    0.539    2.647    0.008
##     LE2d_Confidenc    1.164    0.493    2.360    0.018
##     LE2e_Confidenc    0.855    0.407    2.101    0.036
##     LE2f_Confidenc    1.419    0.597    2.378    0.017
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .LE2a_Confidenc    1.221    0.403    3.033    0.002
##    .LE2b_Confidenc    2.313    0.691    3.345    0.001
##    .LE2c_Confidenc    1.539    0.593    2.595    0.009
##    .LE2d_Confidenc    1.975    0.627    3.151    0.002
##    .LE2e_Confidenc    1.656    0.492    3.364    0.001
##    .LE2f_Confidenc    2.840    0.907    3.131    0.002
##     LE2               0.769    0.482    1.596    0.110
```

Table 13: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| LE2 | LE2a_Confidence | 1.000 | 0.000 | NA | NA | 0.622 |
| LE2 | LE2b_Confidence | 1.036 | 0.486 | 2.131 | 0.033 | 0.513 |
| LE2 | LE2c_Confidence | 1.428 | 0.539 | 2.647 | 0.008 | 0.710 |
| LE2 | LE2d_Confidence | 1.164 | 0.493 | 2.360 | 0.018 | 0.587 |
| LE2 | LE2e_Confidence | 0.855 | 0.407 | 2.101 | 0.036 | 0.503 |
| LE2 | LE2f_Confidence | 1.419 | 0.597 | 2.378 | 0.017 | 0.594 |

In the second subdomain, the p-value is 0.028<0.05, so we will drop the question LE2a to see how the model will be.

```
## lavaan 0.6-5 ended normally after 30 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         10
##
##                                                   Used       Total
##   Number of observations                            29          84
##
## Model Test User Model:
##
##   Test statistic                                 1.583
##   Degrees of freedom                                 5
##   P-value (Chi-square)                           0.903
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
```

```
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   LE2 =~
##     LE2b_Confidenc    1.000
##     LE2c_Confidenc    1.065    0.423    2.520    0.012
##     LE2d_Confidenc    0.791    0.363    2.179    0.029
##     LE2e_Confidenc    0.640    0.305    2.098    0.036
##     LE2f_Confidenc    0.871    0.424    2.053    0.040
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .LE2b_Confidenc    1.704    0.642    2.652    0.008
##    .LE2c_Confidenc    1.676    0.675    2.482    0.013
##    .LE2d_Confidenc    2.153    0.662    3.250    0.001
##    .LE2e_Confidenc    1.610    0.485    3.323    0.001
##    .LE2f_Confidenc    3.219    0.959    3.358    0.001
##     LE2               1.354    0.811    1.670    0.095
```

Table 14: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| LE2 | LE2b_Confidence | 1.000 | 0.000 | NA | NA | 0.665 |
| LE2 | LE2c_Confidence | 1.065 | 0.423 | 2.520 | 0.012 | 0.692 |
| LE2 | LE2d_Confidence | 0.791 | 0.363 | 2.179 | 0.029 | 0.532 |
| LE2 | LE2e_Confidence | 0.640 | 0.305 | 2.098 | 0.036 | 0.506 |
| LE2 | LE2f_Confidence | 0.871 | 0.424 | 2.053 | 0.040 | 0.492 |

After dropping the LE2a, we have a p value of 0.9>0.05. So we will keep all the other questions.

## Third Subdomain

```
## lavaan 0.6-5 ended normally after 33 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         14
##
##                                                   Used       Total
##   Number of observations                            29          84
##
## Model Test User Model:
##
##   Test statistic                                20.428
##   Degrees of freedom                                14
##   P-value (Chi-square)                           0.117
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
```

```
##                    Estimate  Std.Err  z-value  P(>|z|)
##   LE3 =~
##     LE3a_Confidenc    1.000
##     LE3b_Confidenc    0.977    0.377    2.593    0.010
##     LE3c_Confidenc    0.273    0.219    1.242    0.214
##     LE3d_Confidenc    0.563    0.326    1.729    0.084
##     LE3e_Confidenc    0.653    0.306    2.132    0.033
##     LE3f_Confidenc    0.679    0.308    2.205    0.027
##     LE3g_Confidenc    0.302    0.246    1.229    0.219
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .LE3a_Confidenc    2.782    1.002    2.778    0.005
##    .LE3b_Confidenc    1.836    0.785    2.340    0.019
##    .LE3c_Confidenc    1.865    0.504    3.700    0.000
##    .LE3d_Confidenc    3.508    0.985    3.561    0.000
##    .LE3e_Confidenc    2.503    0.751    3.335    0.001
##    .LE3f_Confidenc    2.399    0.733    3.272    0.001
##    .LE3g_Confidenc    2.355    0.636    3.703    0.000
##     LE3               2.069    1.248    1.657    0.097
```

Table 15: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| LE3 | LE3a_Confidence | 1.000 | 0.000 | NA | NA | 0.653 |
| LE3 | LE3b_Confidence | 0.977 | 0.377 | 2.593 | 0.010 | 0.720 |
| LE3 | LE3c_Confidence | 0.273 | 0.219 | 1.242 | 0.214 | 0.276 |
| LE3 | LE3d_Confidence | 0.563 | 0.326 | 1.729 | 0.084 | 0.397 |
| LE3 | LE3e_Confidence | 0.653 | 0.306 | 2.132 | 0.033 | 0.511 |
| LE3 | LE3f_Confidence | 0.679 | 0.308 | 2.205 | 0.027 | 0.534 |
| LE3 | LE3g_Confidence | 0.302 | 0.246 | 1.229 | 0.219 | 0.273 |

In the third subdomian,we have a p value of 0.117>0.05, so we will keep all the questions.

## Fourth Subdomain

```
## lavaan 0.6-5 ended normally after 30 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                         10
##
##                                                   Used       Total
##   Number of observations                            29          84
##
## Model Test User Model:
##
##   Test statistic                                 8.065
##   Degrees of freedom                                 5
##   P-value (Chi-square)                           0.153
##
## Parameter Estimates:
##
```

```
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   LE4 =~
##     LE4a_Confidenc    1.000
##     LE4b_Confidenc    0.570    0.215    2.654    0.008
##     LE4c_Confidenc    0.593    0.171    3.466    0.001
##     LE4d_Confidenc    0.869    0.224    3.872    0.000
##     LE4e_Confidenc    0.522    0.229    2.285    0.022
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .LE4a_Confidenc    1.148    0.708    1.622    0.105
##    .LE4b_Confidenc    3.175    0.893    3.555    0.000
##    .LE4c_Confidenc    1.603    0.496    3.234    0.001
##    .LE4d_Confidenc    2.159    0.766    2.820    0.005
##    .LE4e_Confidenc    3.848    1.059    3.635    0.000
##     LE4               3.501    1.345    2.603    0.009
```

Table 16: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| LE4 | LE4a_Confidence | 1.000 | 0.000 | NA | NA | 0.868 |
| LE4 | LE4b_Confidence | 0.570 | 0.215 | 2.654 | 0.008 | 0.513 |
| LE4 | LE4c_Confidence | 0.593 | 0.171 | 3.466 | 0.001 | 0.659 |
| LE4 | LE4d_Confidence | 0.869 | 0.224 | 3.872 | 0.000 | 0.742 |
| LE4 | LE4e_Confidence | 0.522 | 0.229 | 2.285 | 0.022 | 0.446 |

In the fourth subdomain, we have a p value of 0.153. We will keep all the questions in this subdomain.

## Fifth subdomain

```
## lavaan 0.6-5 ended normally after 26 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          8
##
##                                                   Used       Total
##   Number of observations                            29          84
##
## Model Test User Model:
##
##   Test statistic                                 4.188
##   Degrees of freedom                                 2
##   P-value (Chi-square)                           0.123
##
## Parameter Estimates:
##
##   Information                                 Expected
```

```
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   LE5 =~
##     LE5a_Confidenc    1.000
##     LE5b_Confidenc    0.570    0.243    2.343    0.019
##     LE5c_Confidenc    1.325    0.474    2.794    0.005
##     LE5d_Confidenc    0.629    0.289    2.178    0.029
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .LE5a_Confidenc    1.564    0.580    2.696    0.007
##    .LE5b_Confidenc    1.328    0.381    3.487    0.000
##    .LE5c_Confidenc    0.689    0.723    0.952    0.341
##    .LE5d_Confidenc    1.985    0.558    3.557    0.000
##     LE5               1.351    0.765    1.766    0.077
```

Table 17: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| LE5 | LE5a_Confidence | 1.000 | 0.000 | NA | NA | 0.681 |
| LE5 | LE5b_Confidence | 0.570 | 0.243 | 2.343 | 0.019 | 0.498 |
| LE5 | LE5c_Confidence | 1.325 | 0.474 | 2.794 | 0.005 | 0.880 |
| LE5 | LE5d_Confidence | 0.629 | 0.289 | 2.178 | 0.029 | 0.460 |

In the fifth subdomain, we have a p-value of 0.123, so we will keep all the questions in this dubdomain.

## Sixth subdomain

```
## lavaan 0.6-5 ended normally after 37 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of free parameters                          8
##
##                                                   Used       Total
##   Number of observations                            29          84
##
## Model Test User Model:
##
##   Test statistic                                 0.832
##   Degrees of freedom                                 2
##   P-value (Chi-square)                           0.660
##
## Parameter Estimates:
##
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##   Standard errors                             Standard
##
## Latent Variables:
```

```
##                    Estimate  Std.Err  z-value  P(>|z|)
##   LE6 =~
##     LE6a_Confidenc    1.000
##     LE6b_Confidenc    2.725    2.229    1.223    0.222
##     LE6c_Confidenc    2.058    1.717    1.198    0.231
##     LE6d_Confidenc    3.160    2.585    1.222    0.222
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .LE6a_Confidenc    4.983    1.322    3.770    0.000
##    .LE6b_Confidenc    0.807    0.466    1.732    0.083
##    .LE6c_Confidenc    1.545    0.473    3.270    0.001
##    .LE6d_Confidenc    1.195    0.640    1.867    0.062
##     LE6               0.309    0.503    0.614    0.539
```

Table 18: Factor Loadings

| Latent Factor | Indicator | B | SE | Z | p-value | loading |
|---|---|---|---|---|---|---|
| LE6 | LE6a_Confidence | 1.000 | 0.000 | NA | NA | 0.241 |
| LE6 | LE6b_Confidence | 2.725 | 2.229 | 1.223 | 0.222 | 0.860 |
| LE6 | LE6c_Confidence | 2.058 | 1.717 | 1.198 | 0.231 | 0.677 |
| LE6 | LE6d_Confidence | 3.160 | 2.585 | 1.222 | 0.222 | 0.849 |

In the sixth subdomain, the p-value is 0.66>0.05. We will not drop any question in this subdomain.

# Conclusion / Discussion

For PER&FEEDBACK table, I dropped “PF1e_Confidence”,“PF2c_Confidence” and “PF5c_Confidence” so that P-value of all subdomains are greater than 0.05 finally.
For the Learning Experience table, we will only drop “LE2a_Confidence” and keep all the remaining questions in order to let the P-value of all subdomains are greater than 0.05 finally.
For the Learning Experience table, we will only drop “LT3c_Confidence” and keep all the remaining questions in order to let the P-value of all subdomains are greater than 0.05 finally.

## Appendix