Task A) Experimental design

Input in VR is complicated. The researchers want to investigate which input method of the ones that they have available is the best. They developed a virtual keyboard, voice control and selecting text with full-body gestures.

Design an experiment that evaluates text entry capabilities of the three methods for entering the player's name inside a VR game. There are 20 participants that can be recruited for the study.

Formulate a research question:
Is there any difference in the easieness of text inputs between different types of input methods?
(OR) Investigate if different types of writing input methods result in differences of speed in text input.

Define the variables in your experiment. Don't forget about proper operationalization.

The independent variable is Type of input method, with 3 levels.
The independent variable is _____, with ___ levels.
The independent variable is _____, with ___ levels.
The dependent variable is Word per minute
The dependent variable is _____
The dependent variable is _____

There are 3 experimental conditions.
This is a within group experiment design.
Between-subject factors: There is no between subject factor
Within-subject factors: 1

Propose the order of condition assignments for the first three participants:

Participant	Task 1	Task 2	Task 3
1	1	2	3
2	2	1	3
3	3	2	1

?

Define null and alternative hypotheses:

i. H_0:
The data of the three inputs methods comes from the same sampling distribution. This means that the mean word per minute is the same across the three input methods
H_0 = \mu_0 = \mu_1 = mu_2

ii. H_1:
The data of the three inputs methods does not come from the same sampling distribution meaning that at least one mean differ
At least one differ; H_1 at least: \mu_0 \neq \mu_1 or \mu_0 \neq \mu_3 or \mu_1 \neq \mu_3

Calculate degrees of freedom:

b. $df_{between}$= k-1 = 3-1 = 2
c. df_{within}= N-k= 60-3 = 57
d. df_{total}= N-1 =60-1=59

Define *all* the statistical tests you plan to run to analyse the data (assume results are significant):

First, I would run a descriptive statistics on the results; then I would calculate the ANOVA F-test statistics and either use the P- value or the Critical alpha value to check if we can reject the Null Hypothesis. Finally I would perform a Tukey test to individuate the significant interaction between the levels of the IV.

Assume you obtained statistically significant results. Report the result of your tests. Use [MEAN], [SD] etc. for missing values:

Question

Task B) Interpreting results

An airline investigated new ways to entertain airplane passengers. New in-flight entertainment (IFE) systems were installed in two planes, the Boeing 747-800I (B748) and the Embraer E190. Three versions of the system were developed – VR, AR and old boring screen (OBS). The researchers measured, among other things, the duration for which the IFE was used during a 5-hour flight. After the study, the following output was produced by R:

```
model <- aov (TimePlayed ~ Plane * IFEType)
> summary(model)
              Df Sum Sq Mean Sq F value Pr(>F)
Plane          1      7       7   0.015  0.904
IFEType        2 168701   84351 166.849 <2e-16 ***
Plane:IFEType  2    106      53   0.105  0.900
Residuals     66  33366     506
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(model)
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = TimePlayed ~ Plane * IFEType)

$Plane
                diff       lwr      upr     p adj
E190-B748 -0.6388889 -11.21997 9.942189 0.9044112

$IFEType
              diff        lwr        upr p adj
OBS-AR -118.00000 -133.56279 -102.43721     0
VR-AR   -69.04167  -84.60446  -53.47887     0
VR-OBS   48.95833   33.39554   64.52113     0

$`Plane:IFEType`
                          diff        lwr       upr     p adj
E190:AR-B748:AR       2.500000  -24.44197  29.44197 0.9997877
B748:OBS-B748:AR   -116.250000 -143.19197 -89.30803 0.0000000
E190:OBS-B748:AR   -117.250000 -144.19197 -90.30803 0.0000000
B748:VR-B748:AR     -66.083333  -93.02530 -39.14137 0.0000000
E190:VR-B748:AR     -69.500000  -96.44197 -42.55803 0.0000000
B748:OBS-E190:AR   -118.750000 -145.69197 -91.80803 0.0000000
```

```
E190:OBS-E190:AR  -119.750000 -146.69197 -92.80803 0.0000000
B748:VR-E190:AR    -68.583333  -95.52530 -41.64137 0.0000000
E190:VR-E190:AR    -72.000000  -98.94197 -45.05803 0.0000000
E190:OBS-B748:OBS   -1.000000  -27.94197  25.94197 0.9999977
B748:VR-B748:OBS    50.166667   23.22470  77.10863 0.0000110
E190:VR-B748:OBS    46.750000   19.80803  73.69197 0.0000454
B748:VR-E190:OBS    51.166667   24.22470  78.10863 0.0000072
E190:VR-E190:OBS    47.750000   20.80803  74.69197 0.0000301
E190:VR-B748:VR     -3.416667  -30.35863  23.52530 0.9990258

> library(psych)
> describe(data)
           vars  n mean    sd median trimmed   mad min max range skew kurtosis   se
PID           1 72 36.5 20.93   36.5   36.50 26.69   1  72    71 0.00    -1.25 2.47
Plane*        2 72  1.5  0.50    1.5    1.50  0.74   1   2     1 0.00    -2.03 0.06
IFEType*      3 72  2.0  0.82    2.0    2.00  1.48   1   3     2 0.00    -1.54 0.10
TimePlayed    4 72 82.4 53.36   71.5   79.48 68.94  14 169   155 0.35    -1.43 6.29
> describeBy(data,IFEType)
group: AR
           vars  n   mean    sd median trimmed   mad min max range  skew kurtosis   se
PID           1 24  36.50 18.72   36.5    36.5 26.69  13  60    47  0.00    -1.95 3.82
Plane*        2 24   1.50  0.51    1.5     1.5  0.74   1   2     1  0.00    -2.08 0.10
IFEType*      3 24   1.00  0.00    1.0     1.0  0.00   1   1     0   NaN      NaN 0.00
TimePlayed    4 24 144.75 30.96  157.5   149.5 17.05  23 169   146 -2.47     7.11 6.32
------------------------------------------------------------------------------------
---------------
group: OBS
           vars  n  mean    sd median trimmed   mad min max range skew kurtosis   se
PID           1 24 48.50 18.72   48.5   48.50 26.69  25  72    47 0.00    -1.95 3.82
Plane*        2 24  1.50  0.51    1.5    1.50  0.74   1   2     1 0.00    -2.08 0.10
IFEType*      3 24  2.00  0.00    2.0    2.00  0.00   2   2     0  NaN      NaN 0.00
TimePlayed    4 24 26.75  5.12   26.0   26.75  2.97  14  36    22 0.24     0.48 1.04
------------------------------------------------------------------------------------
---------------
group: VR
           vars  n  mean    sd median trimmed   mad min max range skew kurtosis   se
PID           1 24 24.50 18.72   24.5   24.50 26.69   1  48    47 0.00    -1.95 3.82
Plane*        2 24  1.50  0.51    1.5    1.50  0.74   1   2     1 0.00    -2.08 0.10
IFEType*      3 24  3.00  0.00    3.0    3.00  0.00   3   3     0  NaN      NaN 0.00
TimePlayed    4 24 75.71 21.70   74.5   74.15 24.46  36 123    87 0.55    -0.28 4.43
>
> describeBy(data,Plane)
group: B748
           vars  n  mean    sd median trimmed   mad min max range skew kurtosis   se
PID           1 36 18.50 10.54   18.5   18.50 13.34   1  36    35 0.00    -1.30 1.76
Plane*        2 36  1.00  0.00    1.0    1.00  0.00   1   1     0  NaN      NaN 0.00
IFEType*      3 36  2.00  0.83    2.0    2.00  1.48   1   3     2 0.00    -1.58 0.14
TimePlayed    4 36 82.72 56.12   58.0   80.17 51.89  21 169   148 0.35    -1.57 9.35
------------------------------------------------------------------------------------
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group: E190
           vars  n  mean    sd median trimmed   mad min max range skew kurtosis   se
PID           1 36 54.50 10.54   54.5   54.50 13.34  37  72    35 0.00    -1.30 1.76
Plane*        2 36  2.00  0.00    2.0    2.00  0.00   2   2     0  NaN      NaN 0.00
IFEType*      3 36  2.00  0.83    2.0    2.00  1.48   1   3     2 0.00    -1.58 0.14
TimePlayed    4 36 82.08 51.26   74.5   79.87 71.91  14 169   155 0.33    -1.38 8.54

> describeBy(data,IFEType:Plane)
group: AR:B748
           vars  n  mean    sd median trimmed   mad min max range  skew kurtosis    se
PID           1 12  18.5  3.61   18.5    18.5  4.45  13  24    11  0.00    -1.50  1.04
Plane*        2 12   1.0  0.00    1.0     1.0  0.00   1   1     0   NaN      NaN  0.00
IFEType*      3 12   1.0  0.00    1.0     1.0  0.00   1   1     0   NaN      NaN  0.00
TimePlayed    4 12 143.5 41.23  158.0   153.0 15.57  23 169   146 -2.01     3.14 11.90
------------------------------------------------------------------------------------
---------------
group: AR:E190
           vars  n  mean    sd median trimmed   mad min max range  skew kurtosis   se
PID           1 12  54.5  3.61   54.5    54.5  4.45  49  60    11  0.00    -1.50 1.04
Plane*        2 12   2.0  0.00    2.0     2.0  0.00   2   2     0   NaN      NaN 0.00
IFEType*      3 12   1.0  0.00    1.0     1.0  0.00   1   1     0   NaN      NaN 0.00
TimePlayed    4 12 146.0 17.36  148.5   146.0 22.24 123 169    46 -0.15    -1.67 5.01
------------------------------------------------------------------------------------
---------------
group: OBS:B748
           vars  n  mean   sd median trimmed  mad min max range skew kurtosis   se
```

```
PID           1 12 30.50 3.61   30.5    30.5 4.45  25  36    11 0.00    -1.50 1.04
Plane*        2 12  1.00 0.00    1.0     1.0 0.00   1   1     0  NaN      NaN 0.00
IFEType*      3 12  2.00 0.00    2.0     2.0 0.00   2   2     0  NaN      NaN 0.00
TimePlayed    4 12 27.25 5.45   25.0    27.0 1.48  21  36    15 0.82    -1.13 1.57
------------------------------------------------------------------------------------
---------------
group: OBS:E190
           vars  n  mean   sd median trimmed  mad min max range  skew kurtosis   se
PID           1 12 66.50 3.61   66.5    66.5 4.45  61  72    11  0.00    -1.50 1.04
Plane*        2 12  2.00 0.00    2.0     2.0 0.00   2   2     0   NaN      NaN 0.00
IFEType*      3 12  2.00 0.00    2.0     2.0 0.00   2   2     0   NaN      NaN 0.00
TimePlayed    4 12 26.25 4.96   26.0    26.5 2.97  14  36    22 -0.61     1.37 1.43
------------------------------------------------------------------------------------
---------------
group: VR:B748
           vars  n  mean    sd median trimmed   mad min max range skew kurtosis   se
PID           1 12  6.50  3.61    6.5     6.5  4.45   1  12    11 0.00    -1.50 1.04
Plane*        2 12  1.00  0.00    1.0     1.0  0.00   1   1     0  NaN      NaN 0.00
IFEType*      3 12  3.00  0.00    3.0     3.0  0.00   3   3     0  NaN      NaN 0.00
TimePlayed    4 12 77.42 29.56   68.0    77.0 32.62  36 123    87 0.28    -1.53 8.53
------------------------------------------------------------------------------------
---------------
group: VR:E190
           vars  n mean    sd median trimmed   mad min max range skew kurtosis   se
PID           1 12 42.5  3.61   42.5    42.5  4.45  37  48    11 0.00     -1.5 1.04
Plane*        2 12  2.0  0.00    2.0     2.0  0.00   2   2     0  NaN      NaN 0.00
IFEType*      3 12  3.0  0.00    3.0     3.0  0.00   3   3     0  NaN      NaN 0.00
TimePlayed    4 12 74.0 10.21   74.5    73.6 11.86  58  94    36 0.35     -0.9 2.95
```

First, some info about the DVs and IVs:

The independent variable is Type of in-flight entertaiment, with 3 levels.
The independent variable is Airplane model, with 2 levels.
The independent variable is _____, with ___ levels.
The dependent variable is Usage of entertainment in minutes (i.e. Time Played)
The dependent variable is _____
The dependent variable is _____

There are 3 * 2 = 6 experimental conditions.
This is a between experiment design.
Between-subject factors: 2
Within-subject factors: 0

Define null and alternative hypotheses:

i. H_0:
There is no significant difference in the mean usage due to plan type

ii. H_1:

iii. H_0:
There is no significant difference in the mean usage due to type of enter

iv. H_1:

v. H_0:
There is no significant interatcion of game and plane type

vi. H_1:

Report degrees of freedom:

e. $df_{between}$= k-1 = 6 - 1= 5

f. df_{within}= N-k = 72-6 = 66

g. df_{total}= N - 1= 72 - 1 = 71

Name *all* the statistical tests ran:
Descriptive statistics/ ANOVA table; F-1 test; Tukey test

Report the results of the experiment. Be thorough.

There is a significant main effect of the IV Inflight Entertainment system on the DV (Time played) (F = 166, p<0.001). There is no significant effect of the IV Airplane Model on the DV, nor there is any effect in the interaction variable between model of airplane and type of entertainment system.
The post-hoc Tukey test shows us that the conclusions stated above still holds: holding type of entertainemnt system fixed, between airplane models there is no significant difference in the usage of the Entertaiment systems (DV Time Played). However, both between and within airplane model, there is a significant difference when when different types of entertainment systems are used (p values close to 0 in all tests)

Sketch graph(s) that would visualise the results of the experiment nicely.

Finally, what are you recommendations for the airline based on the experiment?

My recommendation to the airline, based on the experiment above, is to implement AR inflight entertainment system. As a matter of fact, the mean minutes of usage of this system is 144 minutes. I further recommend not to make any investment on the model of airplane, as this factor does not have any significant difference in the “maximisation” of minutes of entertainment used