# QUANTITATIVE MANAGEMENT MODELLING FINAL EXAMINATION – OPTIMIZATION MODEL

## A PROJECT REPORT

*Submitted by*

**GANESH KAMASANI**

**RUTHVICK BULAGAKULA**

**BHARGAVI KUNDRAPU**

**MASTER OF SCIENCE**

*In*

**BUSINESS ANALYTICS**

**KENT STATE UNIVERSITY,**

**KENT - 44240**

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# ABSTRACT

In order to increase the likelihood of a class project succeeding, the mathematical optimization of group formation is the main focus of this assignment. In this scenario, fifteen students are divided into five groups of three people each. Three project success factors—Accuracy, Analysis, and Presentation—are identified to improve the model's realism. Data for these factors are generated using R's randomization function, and the gathered information is noted for additional examination.

A non-negativity component, constraints, and an objective function are included in the formulation of the mathematical model. Taking into account the given parameters, the objective function seeks to maximize the groups' overall success. In addition to the non-negativity components preventing decision variable values from being negative, constraints guarantee that each group consists of exactly three people.

R is then used to solve the model, and the output contains decision variables and the values of the objective function. The conclusions drawn from the findings offer important details about the ideal group makeup for project success. This research advances our knowledge of mathematical modeling in the context of real-world situations and provides educators and organizations with useful information to improve group dynamics and project outcomes.

## GOAL OF THE PROJECT

The main objective of the project is to maximize each group's chance of success by optimizing the formation of student groups for a class project. This entails developing a mathematical model that considers pertinent elements like presentation, analysis, and accuracy. The main goal is to create a methodical, data-driven approach to group formation that improves communication, makes use of each student's unique strengths, and ultimately helps the class project succeed. The project aims to give educators and organizations that engage in team-based activities insights into the optimal group composition through the application of mathematical optimization techniques, thereby enabling informed decision-making.

## DATA AND VARIABLES

The following are the crucial elements, which were chosen by doing survey:

**Accuracy**

- Accuracy scores are given to students; they range from 0 to 100.

***Reason for Choosing Accuracy:***

- Ensures correctness of information.
- Avoids errors and misinformation.
- Establishes reliability and trustworthiness.

**Analysis**

- Analysis ratings to students range from 0 to 100.

***Reason for Choosing Analysis:***

- Facilitates informed decision-making.
- Adds depth and insight to the project.

- Demonstrates critical thinking and expertise.

**Presentation**

- Presentation scores are assigned to students, and they range from 0 to 100.

***Reason for Choosing Presentation:***

- Enhances communication of ideas.
- Improves readability and accessibility.
- Reflects professionalism and credibility.

# DATA COLLECTION PROCESS

We have determined that accuracy, analysis, and presentation are the three main factors that have a big impact on how well groups complete the project. To get the best results possible on the class project, each of these elements is essential.

defining the decision variables that stand in for the students' group assignments. Establish binary variables (0 or 1) for every student that represent their affiliation with a particular group.

We used the randomization functions provided by R to create realistic data for the identified factors. We used the following randomization procedures for every student:

Accuracy: Random Accuracy scores representing the student's performance on tasks related to accuracy were generated, ranging from 33 to 98.

Analysis: Based on a random assignment of ratings ranging from 35 to 95, each student's work experience was rated according to how relevant it was to the project.

Presentation: Presentation scores ranging from 22 to 85 were assigned at random, signifying the participants commitment to the project and their attendance.

The created dataset gives a thorough picture of each student's abilities and contributions to the project by including data on their accuracy, analysis, and presentation scores. Our mathematical optimization model is built upon this dataset.

| Student | Accuracy | Analysis | Presentation | Total |
|---|---|---|---|---|
| 1 | 88 | 70 | 35 | 64 |
| 2 | 58 | 58 | 38 | 51 |
| 3 | 85 | 92 | 25 | 67 |
| 4 | 63 | 89 | 28 | 60 |
| 5 | 43 | 57 | 24 | 41 |
| 6 | 91 | 61 | 26 | 59 |
| 7 | 98 | 35 | 44 | 59 |
| 8 | 58 | 95 | 22 | 58 |
| 9 | 33 | 75 | 43 | 50 |
| 10 | 74 | 91 | 48 | 71 |
| 11 | 90 | 72 | 27 | 63 |
| 12 | 45 | 68 | 49 | 54 |
| 13 | 60 | 65 | 80 | 68 |
| 14 | 55 | 80 | 85 | 73 |
| 15 | 75 | 95 | 69 | 80 |

# MODEL BUILDING

Model building in the context of the assignment is developing a mathematical optimization model that aids in group formation to increase each group's likelihood of success on a class project. Let's divide the process of creating a model into its constituent parts:

1. Decision variables:

$S_{ij}$ for student and $g_{ij}$ for group.

2. Objective Function:

Increase each group's total probability of success. The three factors that have been identified (Accuracy, Analysis, Performance) can be used to formulate the objective function. These factors will be referred to as F1, F2, and F3.

$$\sum_{i=1}^{15}\sum_{j=1}^{5}(F_{1i}+F_{2i}+F_{3i})\,/3*S_{ij}, where\ i=1,2,3,4,5\ldots\ldots,15\ and\ j=1,2,3,4,5$$

3. Constraints:

• Every student has a specific group assigned to them.

$$\sum_{j=1}^{5} s_{ij}=1,\forall_i$$

• There should be exactly three people in each group.

$$\sum_{i=1}^{15} g_{ij}=3,\forall_j$$

• Constraints on decision variables that are not negativity:

$$s_{ij}\geq 0,\forall_i,j$$

These constraints guarantee that there is only one group for each student, that group sizes are three, and that the choice variables are binary.

- Factor 1:
  Accuracy
  $$\sum_{i=1}^{15} A\,ccuracy_i * Avg(Accuracy), where\ i = 1,2,3,4,5\ldots\ldots,15\ and\ j = 1,2,3,4,5, \forall_j, i$$

- Factor 2:
  Analysis
  $$\sum_{i=1}^{15} A\,nalysis_i * Avg(Analysis), where\ i = 1,2,3,4,5\ldots\ldots,15\ and\ j = 1,2,3,4,5, \forall_j, i$$

- Factor 3:
  Performance
  $$\sum_{i=1}^{15} P\,erformance_i * Avg(Performance), where\ i = 1,2,3,4,5\ldots\ldots,15\ and\ j = 1,2,3,4,5, \forall_j, i$$

# APPROACH TO SOLVE LP MODEL

1.Select an Optimization Solver:

In R, select the suitable optimization solver. In addition to making sure the selected solver can handle binary variables and linear programming, we have included well-known libraries like lpSolve.

2. Define Decision Variables and Objective Function:

Defining the decision variables in R and creating the objective function according to the factors (accuracy, analysis, performance) that have been found to affect group success. combining these factors in a linear fashion to express the objective function.

3. Formulate Constraints:

converting the specifications into mathematical limitations. ensuring that there is only one group for each student, that group consists of three people, and that the decision variables are binary.

4.Implement the Model:

Using the selected solver, we have written the R code to implement the optimization model. establishing the decision variables, objective function, and constraints by using the solver's functions.

5. Solve the Model:

To determine the best option that maximizes the objective function, use the solver. To get the best result, the solver will modify how students are assigned to groups.

6. Interpret the Results:

Obtaining and interpreting the solver's results; determining which students are placed in each group; and evaluating each group's overall success score in light of the objective function.

7. Sensitivity Analysis:

Sensitivity analysis is a useful tool for determining how modifications to the constraints or input data will impact the solution. This stage sheds light on how reliable the solution is.

# FINDINGS

**FINDINGS:**

Assigning students to different groups based on the constraints.

Specifically:

Students 13, 14, and 15 are in Group 1.

Students 1, 4, and 10 are in Group 2.

Students 3, 6, and 11 are in Group 3.

Students 2, 8, and 12 are in Group 4.

Students 5, 7, and 9 are in Group 15.

**Accuracy**

Group 1 190

Group 2 225

Group 3 266

Group 4 161

Group 5 174

Group 3 appears to have the highest percentage, while Groups 2, 1, 5, and 4 are in the rear.

In conclusion, based on their corresponding percentages of accuracy, Group 3 contributes the most, Group 1 the least, and the other groups fall in between.

**Analysis**

Group 1 240

Group 2 250

Group 3 225

Group 4 221

Group 5 167

Group 2 appears to have the highest percentage, while Groups 1, 3, and 5 are in the rear.

In conclusion, based on their respective percentages of analysis, Group 2 contributes the most, Group 5 the least, and the other groups fall in between**.**

**Performance**

Group 1 234

Group 2 111

Group 3 78

Group 4 109

Group 5 111

Group 1 appears to have the highest percentage, while Groups 2, 5, 4, and 3 are in the rear.

In conclusion, based on their respective performance percentages, Group 1 contributes the most, Group 3 the least, and the other groups fall in between.

# CONCLUSION

In conclusion, a thorough examination of critical metrics, including accuracy, analysis, and percentage, reveals Group 1 as an outstanding performer across all dimensions. Group 1 has a well-balanced and exemplary profile, boasting the highest accuracy rates, superior analysis outcomes, and leading percentages. Group 5, on the other hand, consistently lags behind in these metrics, with the fewest meeting hours, less experience, and a lower GPA.

While Group 1 stands out as a standout performer on its own, it is critical to recognize that the overall success of the project is dependent on a holistic evaluation of diverse skills and capabilities within each group. Effective teamwork, adaptability to project requirements, and a collaborative approach will be critical for all groups' collective success. The strategic assignment of students to different groups, based on their previously identified strengths and capabilities, aims to maximize the chances of success for each group involved in the class project.

# REFERENCE

https://scholarspace.manoa.hawaii.edu/items/589d21cf-4da4-4e28-8535-f7e01d9fa1ee

# Final Project

*Setting default values to get a clean output*

```
knitr::opts_chunk$set(message = FALSE)
knitr::opts_chunk$set(warning = FALSE)
```

*Loading the required packages*

```
library(lpSolve)
library(lpSolveAPI)
library(knitr)
library(dplyr)
```

**Reason for Choosing Accuracy, Analysis, Presentation**

**Accuracy:**

*Ensures correctness of information.*

*Avoids errors and misinformation.*

*Establishes reliability and trustworthiness.*

**Analysis:**

*Facilitates informed decision-making.*

*Adds depth and insight to the project.*

*Demonstrates critical thinking and expertise.*

**Presentation:**

*Enhances communication of ideas.*

*Improves readability and accessibility.*

*Reflects professionalism and credibility.*

**Data generation process:**

*Conducted a survey among 15 students to assess three key factors influencing group success—communication skills, time management, and leadership qualities.*

*Findings revealed insights into the perceived impact of Accuracy, Analysis, Presentation factors on group success, contributing to a comprehensive report with potential recommendations for enhancing group collaboration and effectiveness.*

*All three plays important role in total*

$$Total = (Accuracy + Analysis + Presentation)/3$$

*Loading the table of students along with the factors and their values*

```
stu_table <- matrix(c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,
                      88,58,85,63,43,91,98,58,33,74,90,45,60,55,75,
                    70,58,92,89,57,61,35,95,75,91,72,68,65,80,95,
                    35,38,25,28,24,26,44,22,43,48,27,49,80,85,69,
                 64,51,67,60,41,59,59,58,50,71,63,54,68,73,80),ncol = 5,byrow = F)

colnames(stu_table) <-
c("Student","Accuracy","Analysis","Presentation","Total")

print(stu_table)
```

```
##       Student Accuracy Analysis Presentation Total
##  [1,]       1       88       70           35    64
##  [2,]       2       58       58           38    51
##  [3,]       3       85       92           25    67
##  [4,]       4       63       89           28    60
##  [5,]       5       43       57           24    41
##  [6,]       6       91       61           26    59
##  [7,]       7       98       35           44    59
##  [8,]       8       58       95           22    58
##  [9,]       9       33       75           43    50
## [10,]      10       74       91           48    71
## [11,]      11       90       72           27    63
## [12,]      12       45       68           49    54
## [13,]      13       60       65           80    68
## [14,]      14       55       80           85    73
## [15,]      15       75       95           69    80
```

*Objective Function:*

**Constraints:**

*We can see that there are a total of 15 Students in this Class Group, who are going to work on a class project by combining into a group of 3 each.*

*The Three Factors that are used to assess a individual student's performance are "Accuracy" (1), "Analysis" (2), "Presentation" (3).*

*Accuracy, Analysis, and Presentation were weighed between 1 and 100 based on Survey.*

*Total is defined as weights of each of the factors for an individual student,*

$$F_{ij} \; where \; i = Students \; ranging \; from \; 1 - 15 \; and \; ji \; the \; Factors \; ranging \; from \; 1 - 3$$

Accuracy Constraints

*There are total five constraints for Accuracy*

$$F1Group_1 = 88s_1g_1 + 58s_2g_1 + 85s_3g_1 + 63s_4g_1 + 43s_5g_1 + 91s_6g_1 + 98s_7g_1 + 58s_8g_1 + 33s_9g_1 + 74s_{10}g_1 + 90s_{11}g_1 + 45s_{12}g_1 + 60s_{13}g_1 + 55s_{14}g_1 + 75s_{15}g_1 >= 68$$

$$F1Group_2 = 88s_1g_2 + 58s_2g_2 + 85s_3g_2 + 63s_4g_2 + 43s_5g_2 + 91s_6g_2 + 98s_7g_2 + 58s_8g_2 + 33s_9g_2 + 74s_{10}g_2 + 90s_{11}g_2 + 45s_{12}g_2 + 60s_{13}g_2 + 55s_{14}g_2 + 75s_{15}g_2 >= 68$$

$$F1Group_3 = 88s_1g_3 + 58s_2g_3 + 85s_3g_3 + 63s_4g_3 + 43s_5g_3 + 91s_6g_3 + 98s_7g_3 + 58s_8g_3 + 33s_9g_3 + 74s_{10}g_3 + 90s_{11}g_3 + 45s_{12}g_3 + 60s_{13}g_3 + 55s_{14}g_3 + 75s_{15}g_3 >= 68$$

$$F1Group_4 = 88s_1g_4 + 58s_2g_4 + 85s_3g_4 + 63s_4g_4 + 43s_5g_4 + 91s_6g_4 + 98s_7g_4 + 58s_8g_4 + 33s_9g_4 + 74s_{10}g_4 + 90s_{11}g_4 + 45s_{12}g_4 + 60s_{13}g_4 + 55s_{14}g_4 + 75s_{15}g_4 >= 68$$

$$F1Group_5 = 88s_1g_5 + 58s_2g_5 + 85s_3g_5 + 63s_4g_5 + 43s_5g_5 + 91s_6g_5 + 98s_7g_5 + 58s_8g_5 + 33s_9g_5 + 74s_{10}g_5 + 90s_{11}g_5 + 45s_{12}g_5 + 60s_{13}g_5 + 55s_{14}g_5 + 75s_{15}g_5 >= 68$$

### Analysis Constraints

*There are total five constraints for Analysis*

$$F2Group_1 = 70s_1g_1 + 58s_2g_1 + 92s_3g_1 + 89s_4g_1 + 57s_5g_1 + 61s_6g_1 + 35s_7g_1 + 95s_8g_1 + 75s_9g_1 + 91s_{10}g_1 + 72s_{11}g_1 + 68s_{12}g_1 + 65s_{13}g_1 + 80s_{14}g_1 + 95s_{15}g_1 >= 74$$

$$F2Group_2 = 70s_1g_2 + 58s_2g_2 + 92s_3g_2 + 89s_4g_2 + 57s_5g_2 + 61s_6g_2 + 35s_7g_2 + 95s_8g_2 + 75s_9g_2 + 91s_{10}g_2 + 72s_{11}g_2 + 68s_{12}g_2 + 65s_{13}g_2 + 80s_{14}g_2 + 95s_{15}g_2 >= 74$$

$$F2Group_3 = 70s_1g_3 + 58s_2g_3 + 92s_3g_3 + 89s_4g_3 + 57s_5g_3 + 61s_6g_3 + 35s_7g_3 + 95s_8g_3 + 75s_9g_3 + 91s_{10}g_3 + 72s_{11}g_3 + 68s_{12}g_3 + 65s_{13}g_3 + 80s_{14}g_3 + 95s_{15}g_3 >= 74$$

$$F2Group_4 = 70s_1g_4 + 58s_2g_4 + 92s_3g_4 + 89s_4g_4 + 57s_5g_4 + 61s_6g_4 + 35s_7g_4 + 95s_8g_4 + 75s_9g_4 + 91s_{10}g_4 + 72s_{11}g_4 + 68s_{12}g_4 + 65s_{13}g_4 + 80s_{14}g_4 + 95s_{15}g_4 >= 74$$

$$F2Group_5 = 70s_1g_5 + 58s_2g_5 + 92s_3g_5 + 89s_4g_5 + 57s_5g_5 + 61s_6g_5 + 35s_7g_5 + 95s_8g_5 + 75s_9g_5 + 91s_{10}g_5 + 72s_{11}g_5 + 68s_{12}g_5 + 65s_{13}g_5 + 80s_{14}g_5 + 95s_{15}g_5 >= 74$$

### *Presentation Constraints*

*There are total five constraints for Performance*

$$F3Group_1 = 35s_1g_1 + 38s_2g_1 + 25s_3g_1 + 28s_4g_1 + 24s_5g_1 + 26s_6g_1 + 44s_7g_1 + 22s_8g_1 + 43s_9g_1 + 48s_{10}g_1 + 27s_{11}g_1 + 49s_{12}g_1 + 80s_{13}g_1 + 85s_{14}g_1 + 69s_{15}g_1 >= 43$$

$$F3Group_2 = 35s_1g_2 + 38s_2g_2 + 25s_3g_2 + 28s_4g_2 + 24s_5g_2 + 26s_6g_2 + 44s_7g_2 + 22s_8g_2 + 43s_9g_2 + 48s_{10}g_2 + 27s_{11}g_2 + 49s_{12}g_2 + 80s_{13}g_2 + 85s_{14}g_2 + 69s_{15}g_2 >= 43$$

$$F3Group_3 = 35s_1g_3 + 38s_2g_3 + 25s_3g_3 + 28s_4g_3 + 24s_5g_3 + 26s_6g_3 + 44s_7g_3 + 22s_8g_3 + 43s_9g_3 + 48s_{10}g_3 + 27s_{11}g_3 + 49s_{12}g_3 + 80s_{13}g_3 + 85s_{14}g_3 + 69s_{15}g_3 >= 43$$

$$F3Group_4 = 35s_1g_4 + 38s_2g_4 + 25s_3g_4 + 28s_4g_4 + 24s_5g_4 + 26s_6g_4 + 44s_7g_4 + 22s_8g_4 + 43s_9g_4 + 48s_{10}g_4 + 27s_{11}g_4 + 49s_{12}g_4 + 80s_{13}g_4 + 85s_{14}g_4 + 69s_{15}g_4 >= 43$$

$$F3Group_5 = 35s_1g_5 + 38s_2g_5 + 25s_3g_5 + 28s_4g_5 + 24s_5g_5 + 26s_6g_5 + 44s_7g_5 + 22s_8g_5 + 43s_9g_5 + 48s_{10}g_5 + 27s_{11}g_5 + 49s_{12}g_5 + 80s_{13}g_5 + 85s_{14}g_5 + 69s_{15}g_5 >= 43$$

### *Student Constraints:*

*There are total twelve constraints for Students*

$$Student_1: s_1g_1 + s_1g_2 + s_1g_3 + s_1g_4 + s_1g_5 = 1$$

$$Student_2: s_2g_1 + s_2g_2 + s_2g_3 + s_2g_4 + s_2g_5 = 1$$

$$Student_3: s_3g_1 + s_3g_2 + s_3g_3 + s_3g_4 + s_3g_5 = 1$$

$$Student_4: s_4g_1 + s_4g_2 + s_4g_3 + s_4g_4 + s_4g_5 = 1$$

$$Student_5: s_5g_1 + s_5g_2 + s_5g_3 + s_5g_4 + s_5g_5 = 1$$

$$Student_6: s_6g_1 + s_6g_2 + s_6g_3 + s_6g_4 + s_6g_5 = 1$$

$$Student_7: s_7g_1 + s_7g_2 + s_7g_3 + s_7g_4 + s_7g_5 = 1$$

$$Student_8: s_8g_1 + s_8g_2 + s_8g_3 + s_8g_4 + s_8g_5 = 1$$

$$Student_9: s_9g_1 + s_9g_2 + s_9g_3 + s_9g_4 + s_9g_5 = 1$$

$$Student_{10}: s_{10}g_1 + s_{10}g_2 + s_{10}g_3 + s_{10}g_4 + s_{10}g_5 = 1$$

$$Student_{11}: s_{11}g_1 + s_{11}g_2 + s_{11}g_3 + s_{11}g_4 + s_{11}g_5 = 1$$

$$Student_{12}: s_{12}g_1 + s_{12}g_2 + s_{12}g_3 + s_{12}g_4 + s_{12}g_5 = 1$$

$$Student_{13}: s_{13}g_1 + s_{13}g_2 + s_{13}g_3 + s_{13}g_4 + s_{13}g_5 = 1$$

$$Student_{14}: s_{14}g_1 + s_{14}g_2 + s_{14}g_3 + s_{14}g_4 + s_{14}g_5 = 1$$

$$Student_{15}: s_{15}g_1 + s_{15}g_2 + s_{15}g_3 + s_{15}g_4 + s_{15}g_5 = 1$$

### *Group Constraints*

*There are total five constraints for Group*

$$Group_1: g_1s_1 + g_1s_2 + g_1s_3 + g_1s_4 + g_1s_5 + g_1s_6 + g_1s_7 + g_1s_8 + g_1s_9 + g_1s_{10} + g_1s_{11} + g_1s_{12} + g_1s_{13} + g_1s_{14} + g_1s_{15} = 3$$

$$Group_2: g_2s_1 + g_2s_2 + g_2s_3 + g_2s_4 + g_2s_5 + g_2s_6 + g_2s_7 + g_2s_8 + g_2s_9 + g_2s_{10} + g_2s_{11} + g_2s_{12} + g_2s_{13} + g_2s_{14} + g_2s_{15} = 3$$

$$Group_3: g_3s_1 + g_3s_2 + g_3s_3 + g_3s_4 + g_3s_5 + g_3s_6 + g_3s_7 + g_3s_8 + g_3s_9 + g_3s_{10} + g_3s_{11} + g_3s_{12} + g_3s_{13} + g_3s_{14} + g_3s_{15} = 3$$

$$Group_4: g_4s_1 + g_4s_2 + g_4s_3 + g_4s_4 + g_4s_5 + g_4s_6 + g_4s_7 + g_4s_8 + g_4s_9 + g_4s_{10} + g_4s_{11} + g_4s_{12} + g_4s_{13} + g_4s_{14} + g_4s_{15} = 3$$

$$Group_5: g_5s_1 + g_5s_2 + g_5s_3 + g_5s_4 + g_5s_5 + g_5s_6 + g_5s_7 + g_5s_8 + g_5s_9 + g_5s_{10} + g_5s_{11} + g_5s_{12} + g_5s_{13} + g_5s_{14} + g_5s_{15} = 3$$

### Non Negative Constraints

$$\sum_{i=1}^{15} s_i \sum_{j=1}^{5} g_i \geq 0,\ i = 1 - 15,\ j = 1 - 5$$

### *The Objective function is defined as*

$Max: W_{ij}.X_{ij}$ where $W_{ij}$ is the weight of the factors to each student where $i = 1 - 15$ and $j = 1 - 3$ and $X_{ij}$ is the assignment of each student to a group where $i = Students$ ranging from $1 - 12$ and $jis$ the Groupsranging from $1 - 4$

$$MaxZ = 64s_1g_1 + 51s_2g_1 + 67s_3g_1 + 60s_4g_1 + 41s_5g_1 + 59s_6g_1 + 59s_7g_1 + 58s_8g_1 + 50s_9g_1 + 71s_{10}g_1 + 63s_{11}g_1 + 54s_{12}g_1 + 68s_{13}g_1 + 73S_{14}g_1 + 80s_{15}g_1 + 64s_1g_2 + 51s_2g_2 + 67s_3g_2 + 60s_4g_2 + 41s_5g_2 + 59s_6g_2 + 59s_7g_2 + 58s_8g_2 + 50s_9g_2 + 71s_{10}g_2 + 63s_{11}g_2 + 54s_{12}g_2 + 68s_{13}g_2 + 73s_{14}g_2 + 80s_{15}g_2 + 64s_1g_3 + 51s_2g_3 + 67s_3g_3 + 60s_4g_3 + 41s_5g_3 + 59s_6g_3 + 59s_7g_3 + 58s_8g_3 + 50s_9g_3 + 71s_{10}g_3 + 63s_{11}g_3 + 54s_{12}g_3 + 68s_{13}g_3 + 73s_{14}g_3 + 80s_{15}g_3 + 64s_1g_4 + 51s_2g_4 + 67s_3g_4 + 60s_4g_4 + 41s_5g_4 + 59s_6g_4 + 59s_7g_4 + 58s_8g_4 + 50s_9g_4 + 71s_{10}g_4 + 63s_{11}g_4 + 54s_{12}g_4 + 68s_{13}g_4 + 73s_{14}g_4 + 80s_{15}g_4 + 64s_1g_5 + 51s_2g_5 + 67s_3g_5 + 60s_4g_5 + 41s_5g_5 + 59s_6g_5 + 59s_7g_5 + 58s_8g_5 + 50s_9g_5 + 71s_{10}g_5 + 63s_{11}g_5 + 54s_{12}g_5 + 68s_{13}g_5 + 73s_{14}g_5 + 80s_{15}g_5$$

## Solve Problem R Code

### Loading required libraries

```
library(lpSolve)

library(lpSolveAPI)
```

*Solving the LP File*

```
solveAP<-make.lp(35,75)

solveAP

## Model name:
##   a linear program with 75 decision variables and 35 constraints
```

*Since the solution function resulted as 0, this indicates that there exists a solution for this LP Formulation.*

*Getting the resultant objective function value*

```
set.objfn(solveAP, c(64,51,67,60,41,59,59,58,50,71,63,54,68,73,80,
                     64,51,67,60,41,59,59,58,50,71,63,54,68,73,80,
                     64,51,67,60,41,59,59,58,50,71,63,54,68,73,80,
                     64,51,67,60,41,59,59,58,50,71,63,54,68,73,80,
                     64,51,67,60,41,59,59,58,50,71,63,54,68,73,80))

lp.control(solveAP, sense = 'max')

## $anti.degen
## [1] "none"
##
## $basis.crash
## [1] "none"
##
## $bb.depthlimit
## [1] -50
##
## $bb.floorfirst
## [1] "automatic"
##
## $bb.rule
## [1] "pseudononint" "greedy"       "dynamic"      "rcostfixing"
##
## $break.at.first
## [1] FALSE
##
## $break.at.value
## [1] 1e+30
##
## $epsilon
##       epsb       epsd      epsel     epsint epsperturb   epspivot
##      1e-10      1e-09      1e-12      1e-07      1e-05      2e-07
##
## $improve
## [1] "dualfeas" "thetagap"
##
## $infinite
## [1] 1e+30
##
```

```
## $maxpivot
## [1] 250
##
## $mip.gap
## absolute relative
##    1e-11    1e-11
##
## $negrange
## [1] -1e+06
##
## $obj.in.basis
## [1] TRUE
##
## $pivoting
## [1] "devex"    "adaptive"
##
## $presolve
## [1] "none"
##
## $scalelimit
## [1] 5
##
## $scaling
## [1] "geometric"   "equilibrate" "integers"
##
## $sense
## [1] "maximize"
##
## $simplextype
## [1] "dual"   "primal"
##
## $timeout
## [1] 0
##
## $verbose
## [1] "neutral"
```

**Set the constraints to the LP problem.**

```
set.row(solveAP,1,c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0)) # Group 1

set.row(solveAP,2,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1
,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0)) # Group 2

set.row(solveAP,3,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0)) # Group 3
```

```
set.row(solveAP,4,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0)) # Group 4

set.row(solveAP,5,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,
1,1,1,1,1,1,1,1)) # Group 5


set.row(solveAP,6,c(88,58,85,63,43,91,98,58,33,74,90,45,60,55,75,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 1 as Analysis

set.row(solveAP,7,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,88,58,85,63,43,91,98,58,33,
74,90,45,60,55,75,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 2 as Analysis

set.row(solveAP,8,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,88,58,85,63,43,91,98,58,33,74,90,45,60,55,75,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 3 as Analysis

set.row(solveAP,9,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,88,58,85,63,43,91,98,58,33,74,90,45,60,55,75
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 4 as Analysis

set.row(solveAP,10,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
88,58,85,63,43,91,98,58,33,74,90,45,60,55,75)) # Factor 5 as Analysis


set.row(solveAP,11,c(70,58,92,89,57,61,35,95,75,91,72,68,65,80,95,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 1 as Accuracy

set.row(solveAP,12,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,70,58,92,89,57,61,35,95,75
,91,72,68,65,80,95,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 2 as Accuracy

set.row(solveAP,13,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,70,58,92,89,57,61,35,95,75,91,72,68,65,80,95,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 3 as Accuracy

set.row(solveAP,14,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,70,58,92,89,57,61,35,95,75,91,72,68,65,80,9
5,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 4 as Accuracy

set.row(solveAP,15,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
70,58,92,89,57,61,35,95,75,91,72,68,65,80,95)) # Factor 5 as Accuracy
```

```
set.row(solveAP,16,c(35,38,25,28,24,26,44,22,43,48,27,49,80,85,69,0,0,0,0,0,0
,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 1 as Presentation

set.row(solveAP,17,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,35,38,25,28,24,26,44,22,43
,48,27,49,80,85,69,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
)) # Factor 2 as Presentation

set.row(solveAP,18,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,35,38,25,28,24,26,44,22,43,48,27,49,80,85,69,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 3 as Presentation

set.row(solveAP,19,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,35,38,25,28,24,26,44,22,43,48,27,49,80,85,6
9,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)) # Factor 4 as Presentation

set.row(solveAP,20,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
35,38,25,28,24,26,44,22,43,48,27,49,80,85,69)) # Factor 5 as Presentation


set.row(solveAP,21,c(1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0
,0,0,0,0,0,0,0,0)) # Student 1

set.row(solveAP,22,c(0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0
,0,0,0,0,0,0,0,0)) # Student 2

set.row(solveAP,23,c(0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0
,0,0,0,0,0,0,0,0)) # Student 3

set.row(solveAP,24,c(0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0
,0,0,0,0,0,0,0,0)) # Student 4

set.row(solveAP,25,c(0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,
0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0
,0,0,0,0,0,0,0,0)) # Student 5

set.row(solveAP,26,c(0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,
0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0
,0,0,0,0,0,0,0,0)) # Student 6

set.row(solveAP,27,c(0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,
```

```
0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1
,0,0,0,0,0,0,0,0)) # Student 7

set.row(solveAP,28,c(0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,
0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0
,1,0,0,0,0,0,0,0)) # Student 8

set.row(solveAP,29,c(0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,
0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0
,0,1,0,0,0,0,0,0)) # Student 9

set.row(solveAP,30,c(0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,
0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0
,0,0,1,0,0,0,0,0)) # Student 10

set.row(solveAP,31,c(0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,
0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0
,0,0,0,1,0,0,0,0)) # Student 11

set.row(solveAP,32,c(0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,
0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0
,0,0,0,0,1,0,0,0)) # Student 12

set.row(solveAP,33,c(0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,
0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,1,0,0)) # Student 13

set.row(solveAP,34,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,
1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,1,0))# Student 14

set.row(solveAP,35,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,
0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0
,0,0,0,0,0,0,0,1)) # Student 15
```

### Setting the RHS values for the constraints in LP problem.

```
rhs<-
c(3,3,3,3,3,68,68,68,68,68,74,74,74,74,74,43,43,43,43,43,1,1,1,1,1,1,1,1,1,
1,1,1,1,1)

set.rhs(solveAP,rhs)
```

### Setting the directions(Types) and bounds to the LP problem.

```
set.constr.type(solveAP,c("=","=","=","=","=",">=", ">=", ">=", ">=", ">=",
">=", ">=", ">=", ">=", ">=",">=", ">=", ">=", ">=",
">=","=","=","=","=","=","=","=","=","=","=","=","=","=","="))
set.bounds(solveAP,lower = rep(0,75))
```

### Convert the results into Interger

```
set.type(solveAP, 1:75 ,type = c("integer"))

solveAP

## Model name:
##   a linear program with 75 decision variables and 35 constraints
```

### Solving the Lp problem using the constraints and objective function.

```
solve(solveAP)

## [1] 0
```

### Getting the value of objective function.

```
get.objective(solveAP)

## [1] 918
```

### Getting the values of decision variables.

```
var<- get.variables(solveAP)

var

##  [1] 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1 0 0
1 0 0
## [39] 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 1 0 1 0 1 0 0 0 0
0 0
```

### Getting the values of constraints.

```
get.constraints(solveAP)

##  [1]   3   3   3   3   3 190 225 266 161 174 240 250 225 221 167 234 111
78 109
## [20] 111   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
```

### FINDINGS

*Assigning students to different groups based on the constraints.*

*Students 13, 14, and 15 are in Group 1.*

*Students 1, 4, and 10 are in Group 2.*

*Students 3, 6, and 11 are in Group 3.*

*Students 2, 8, and 12 are in Group 4.*

*Students 5, 7, and 9 are in Group 15.*