



Quantitative Management Modelling

Final Project - Group-9

Team

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Abstract

This assignment explores mathematical optimization for strategic student group formation, aiming to maximize success in collaborative class projects. With 15 students organized into 5 groups of 3, the study focuses on critical success factors: GPA, Presentation Skill, and Team Participation. Utilizing R's randomization, realistic data is generated, forming a mathematical model. The objective is to optimize each group's success while considering size constraints. The study concludes with R implementation, offering insights into optimal group compositions and recommendations for future formations, highlighting the impactful role of optimization in education.

Goal

This study aims to create an impactful Quantitative Management Model with the primary objective of maximizing group success in collaborative projects. The goal involves identifying and incorporating key factors, such as GPA, Presentation Skill, and Team Participation, recognizing their critical roles as contributors to overall group performance. Through a comprehensive understanding of these factors, the study endeavors to develop an effective model that enhances the collective success of groups within the educational context.

Methodology

The methodology involved formulating a linear programming model to maximize the weighted sum of GPA, Presentation Skill, and Team Participation. Specific constraints were introduced to ensure a structured team composition, individual participation, and adherence to predefined performance thresholds.

We have successfully formed **five groups** among the **15 students** enrolled in the class. Each **group** is meticulously composed of **three members**, aiming to create a balanced and collaborative environment for the upcoming class project. Our primary objective is to **maximize the potential for success within each group**.

To achieve this, three critical factors—GPA, Presentation Skills, and Team Participation—were identified as pivotal in influencing students' contributions to project success. **Leveraging R's randomization function**, we systematically assigned students to their respective groups, ensuring a fair distribution of these factors.

The attached data outlines the individual attributes of each student, including

1. GPA
2. Presentation Skills
3. Team Participation

and an **Overall points score**.

Factor Descriptions

- **GPA (Grade Point Average):** GPA is a crucial metric that reflects a student's academic performance up to the current date. It serves as an indicator of the student's dedication and commitment to their studies, implying a higher likelihood of successful project completion. Moreover, it provides insight into the student's proficiency at the graduate level, making it a pivotal factor influencing project success.

- **Presentation Skills:** Effective presentation skills are essential for the success of a group project. Individuals with strong presentation skills contribute to the project's success by conveying information clearly and persuasively. This factor adds a practical dimension to project solutions and fosters better communication and collaboration within the group. Presentation skills enhance the overall quality of the project delivery, making it a significant contributor to success.
- **Team Participation:** Active participation within a team is a fundamental factor that positively impacts the success of a group project. Students with a history of effective team participation bring valuable collaborative skills to the table. Their ability to work harmoniously with team members, contribute ideas, and engage in meaningful discussions enhances the overall group dynamics. Successful team participation is crucial for the seamless execution of project tasks and achieving shared objectives.

Combining Factors for Success

The objective is to ensure the success of all groups by balancing the distribution of these factors. To achieve this, the sum of each factor within a group should be equal to or greater than the average value of that factor across all students (15 students in total). This constraint applies individually to each factor—GPA, Presentation Skills, and Team Participation. These constraints serve to evenly distribute qualities among the five groups, guaranteeing success for each.

As all three factors positively influence group performance, the aim is to maximize the values of these factors for the success of each group. Among them, GPA is identified as the primary factor leading to group success, and it will be utilized in the objective function for maximization. This strategic

approach ensures that groups are formed with a well-rounded combination of GPA, Presentation Skills, and Team Participation, enhancing the overall potential for success in each project group.

This **comprehensive dataset** reflects our commitment to creating diverse teams, thereby optimizing the collective strengths of each group for a successful class project. This strategic approach acknowledges the importance of a well-rounded skill set within each team, contributing to a collaborative and high-achieving learning environment.

Student ID	Student name	GPA	Presentation Skills	Team Participation	Points
1	Ajeet	3.57	3.14	5	22
2	Jackson	2.02	3.19	4	18
3	Olivia	3.56	3.9	7	26
4	Liam	3.46	3.31	2	19
5	Emma	3.26	3.36	6	23
6	Praveen	2.96	3.78	2	19
7	Lucas	2.31	3.19	10	24
8	Mia	2.02	3.02	6	19
9	Ethan	2.9	3.41	5	21
10	Isabella	2.98	3.48	4	20
11	Aiden	2.78	3.42	9	25
12	Ilokes	2.93	3.34	4	20
13	Logan	3.43	3.87	3	21

Student ID	Student name	GPA	Presentation Skills	Team Participation	Points
14	Amelia	2.11	3.46	2	17
15	Indira	2.71	3.53	2	18

Formulating the Model

Objective Function

Maximizing Group Success:

The objective function (Z) was designed to maximize the collective impact of GPA, Presentation Skill, and Team Participation on overall group success

Maximize:

$3.57G1S1 + 2.02G1S2 + 3.56G1S3 + 3.46G1S4 + 3.26G1S5 + 2.96G1S6 + 2.31G1S7 + 2.02G1S8 + 2.90G1S9 + 2.98G1S10 + 2.78G1S11 + 2.93G1S12 + 3.43G1S13 + 2.11G1S14 + 2.71G1S15 + 3.57G2S1 + 2.02G2S2 + 3.56G2S3 + 3.46G2S4 + 3.26G2S5 + 2.96G2S6 + 2.31G2S7 + 2.02G2S8 + 2.90G2S9 + 2.98G2S10 + 2.78G2S11 + 2.93G2S12 + 3.43G2S13 + 2.11G2S14 + 2.71G2S15 + 3.57G3S1 + 2.02G3S2 + 3.56G3S3 + 3.46G3S4 + 3.26G3S5 + 2.96G3S6 + 2.31G3S7 + 2.02G3S8 + 2.90G3S9 + 2.98G3S10 + 2.78G3S11 + 2.93G3S12 + 3.43G3S13 + 2.11G3S14 + 2.71G3S15 + 3.57G4S1 + 2.02G4S2 + 3.56G4S3 + 3.46G4S4 + 3.26G4S5 + 2.96G4S6 + 2.31G4S7 + 2.02G4S8 + 2.90G4S9 + 2.98G4S10 + 2.78G4S11 + 2.93G4S12 + 3.43G4S13 + 2.11G4S14 + 2.71G4S15 + 3.57G5S1 + 2.02G5S2 + 3.56G5S3 + 3.46G5S4 + 3.26G5S5 + 2.96G5S6 + 2.31G5S7 + 2.02G5S8 + 2.90G5S9 + 2.98G5S10 + 2.78G5S11 + 2.93G5S12 + 3.43G5S13 + 2.11G5S14 + 2.71G5S15;$

Constraints:

Student_Group1: $G1S1 + G1S2 + G1S3 + G1S4 + G1S5 + G1S6 + G1S7 + G1S8 + G1S9 + G1S10 + G1S11 + G1S12 + G1S13 + G1S14 + G1S15 = 3;$

Student_Group2: G2S1 +G2S2 +G2S3 +G2S4 +G2S5 +G2S6 +G2S7 +G2S8 +G2S9
+G2S10 +G2S11 +G2S12 +G2S13 +G2S14 +G2S15 = 3;

Student_Group3: G3S1 +G3S2 +G3S3 +G3S4 +G3S5 +G3S6 +G3S7 +G3S8 +G3S9
+G3S10 +G3S11 +G3S12 +G3S13 +G3S14 +G3S15 = 3;

Student_Group4: G4S1 +G4S2 +G4S3 +G4S4 +G4S5 +G4S6 +G4S7 +G4S8 +G4S9
+G4S10 +G4S11 +G4S12 +G4S13 +G4S14 +G4S15 = 3;

Student_Group5: G5S1 +G5S2 +G5S3 +G5S4 +G5S5 +G5S6 +G5S7 +G5S8 +G5S9
+G5S10 +G5S11 +G5S12 +G5S13 +G5S14 +G5S15 = 3;

Student Constraints:

Student	Group 1	Group 2	Group 3	Group 4	Group 5
Student_1	G1S1	G2S1	G3S1	G4S1	G5S1
Student_2	G1S2	G2S2	G3S2	G4S2	G5S2
Student_3	G1S3	G2S3	G3S3	G4S3	G5S3
Student_4	G1S4	G2S4	G3S4	G4S4	G5S4
Student_5	G1S5	G2S5	G3S5	G4S5	G5S5
Student_6	G1S6	G2S6	G3S6	G4S6	G5S6
Student_7	G1S7	G2S7	G3S7	G4S7	G5S7
Student_8	G1S8	G2S8	G3S8	G4S8	G5S8
Student_9	G1S9	G2S9	G3S9	G4S9	G5S9
Student_10	G1S10	G2S10	G3S10	G4S10	G5S10
Student_11	G1S11	G2S11	G3S11	G4S11	G5S11
Student_12	G1S12	G2S12	G3S12	G4S12	G5S12
Student_13	G1S13	G2S13	G3S13	G4S13	G5S13
Student_14	G1S14	G2S14	G3S14	G4S14	G5S14
Student_15	G1S15	G2S15	G3S15	G4S15	G5S15

GPA Constraints:

Group1_GPA:

$3.57G1S1+2.02G1S2+3.56G1S3+3.46G1S4+3.26G1S5+2.96G1S6+2.31G1S7+2.02G1S8+2.90G1S9+2.98G1S10+2.78G1S11+2.93G1S12+3.43G1S13+2.11G1S14+2.71G1S15 \geq 2.86;$

Group2_GPA:

$3.57G2S1+2.02G2S2+3.56G2S3+3.46G2S4+3.26G2S5+2.96G2S6+2.31G2S7+2.02G2S8+2.90G2S9+2.98G2S10+2.78G2S11+2.93G2S12+3.43G2S13+2.11G2S14+2.71G2S15 \geq 2.86;$

Group3_GPA:

$3.57G3S1+2.02G3S2+3.56G3S3+3.46G3S4+3.26G3S5+2.96G3S6+2.31G3S7+2.02G3S8+2.90G3S9+2.98G3S10+2.78G3S11+2.93G3S12+3.43G3S13+2.11G3S14+2.71G3S15 \geq 2.86;$

Group4_GPA:

$3.57G4S1+2.02G4S2+3.56G4S3+3.46G4S4+3.26G4S5+2.96G4S6+2.31G4S7+2.02G4S8+2.90G4S9+2.98G4S10+2.78G4S11+2.93G4S12+3.43G4S13+2.11G4S14+2.71G4S15 \geq 2.86;$

Group5_GPA:

$3.57G5S1+2.02G5S2+3.56G5S3+3.46G5S4+3.26G5S5+2.96G5S6+2.31G5S7+2.02G5S8+2.90G5S9+2.98G5S10+2.78G5S11+2.93G5S12+3.43G5S13+2.11G5S14+2.71G5S15 \geq 2.86;$

Presentation Skills:

Group1_Presentation_skill:

$3.14G1S1+3.19G1S2+3.90G1S3+3.31G1S4+3.36G1S5+3.78G1S6+3.19G1S7+3.02G1S8+3.41G1S9+3.48G1S10+3.42G1S11+3.34G1S12+3.87G1S13+3.46G1S14+3.53G1S15 \geq 3.42;$

Group2_Presentation_skill:

$3.14G2S1+3.19G2S2+3.90G2S3+3.31G2S4+3.36G2S5+3.78G2S6+3.19G2S7+3.02G2S8+3.41G2S9+3.48G2S10+3.42G2S11+3.34G2S12+3.87G2S13+3.46G2S14+3.53G2S15 \geq 3.42;$

Group3_Presentation_skill:

$3.14G3S1+3.19G3S2+3.90G3S3+3.31G3S4+3.36G3S5+3.78G3S6+3.19G3S7+3.02G3S8+3.41G3S9+3.48G3S10+3.42G3S11+3.34G3S12+3.87G3S13+3.46G3S14+3.53G3S15 \geq 3.42;$

Group4_Presentation_skill:

$3.14G4S1+3.19G4S2+3.90G4S3+3.31G4S4+3.36G4S5+3.78G4S6+3.19G4S7+3.02G4S8+3.41G4S9+3.48G4S10+3.42G4S11+3.34G4S12+3.87G4S13+3.46G4S14+3.53G4S15 \geq 3.42;$

Group5_Presentation_skill:

$3.14G5S1+3.19G5S2+3.90G5S3+3.31G5S4+3.36G5S5+3.78G5S6+3.19G5S7+3.02G5S8+3.41G5S9+3.48G5S10+3.42G5S11+3.34G5S12+3.87G5S13+3.46G5S14+3.53G5S15 \geq 3.42;$

Team Participation:**Group1_Team_Participation:**

$5G1S1+4G1S2+7G1S3+2G1S4+6G1S5+2G1S6+10G1S7+6G1S8+5G1S9+4G1S10+9G1S11+4G1S12+3G1S13+2G1S14+2G1S15 \geq 4.73;$

Group2_Team_Participation:

$5G2S1+4G2S2+7G2S3+2G2S4+6G2S5+2G2S6+10G2S7+6G2S8+5G2S9+4G2S10+9G2S11+4G2S12+3G2S13+2G2S14+2G2S15 \geq 4.73;$

Group3_Team_Participation:

$5G3S1+4G3S2+7G3S3+2G3S4+6G3S5+2G3S6+10G3S7+6G3S8+5G3S9+4G3S10+9G3S11+4G3S12+3G3S13+2G3S14+2G3S15 \geq 4.73;$

Group4_Team_Participation:

$5G4S1+4G4S2+7G4S3+2G4S4+6G4S5+2G4S6+10G4S7+6G4S8+5G4S9+4G4S10+9G4S11+4G4S12+3G4S13+2G4S14+2G4S15 \geq 4.73;$

Group5_Team_Participation:

$5G5S1+4G5S2+7G5S3+2G5S4+6G5S5+2G5S6+10G5S7+6G5S8+5G5S9+4G5S10+9G5S11+4G5S12+3G5S13+2G5S14+2G5S15 \geq 4.73;$

Constraints for each group can be established based on the information provided in the table above in the following manner:

Consider a student denoted by x_{ij} , where i = represents the Student ID and j = signifies the Group number. The variable x_{ij} takes a value of 1 or 0, indicating the presence or absence of a specific student in a particular group.

Total number of students in a group should be 3 members:

$$\sum_{i=1}^{15} x_{ij} = 3 \quad \forall j \in (1, 2, 3, 4, 5)$$

An individual must belong to a single group and cannot be a member of more than one group:

$$\sum_{j=1}^5 x_{ij} = 1 \quad \forall i \in (1, 2, 3, 4, \dots, 14, 15)$$

GPA constraint:

$$\sum_{i=1}^{15} G_i * x_{ij} \geq 2.86 \quad \forall j \in (1, 2, 3, 4, 5), \text{ where } G_i = \text{GPA of students}$$

Presentation skill:

$$\sum_{i=1}^{15} A_i * x_{ij} \geq 3.42 \quad \forall j \in (1, 2, 3, 4, 5), \text{ where } A_i = \text{Presentation skill of students}$$

Team Participation:

$$\sum_{i=1}^{15} Aw_i * x_{ij} \geq 4.73, \text{ where } Aw_i = \text{Team Participation of students}$$

Non-negative of variables:

$$x_{ij} \geq 0 \quad \text{where } i = 1, 2, \dots, 14, 15 \quad j = 1, 2, 3, 4, 5$$

Solving the Model

We devised the linear programming framework by formulating the objective function for 75 decision variables, optimizing for maximization. The objective sense was set to maximize, and we introduced constraints related to groups, students, and factors—amounting to a total of 35 constraints. This comprehensive approach ensures a well-structured and effective linear programming problem for our analysis.

```
Val_Data1=data.frame(Factors=c('GPA','Presentation skill','Team Participation'),
                        'Target'= c('>=2.86','>=3.42','>=4.73'),
                        check.names = FALSE)
Val_Data1
```

```
##           Factors Target
## 1           GPA >=2.86
## 2 Presentation skill >=3.42
## 3 Team Participation >=4.73
```

```
library(lpSolveAPI)
```

```
## Warning: package 'lpSolveAPI' was built under R version 4.2.3
```

```
# Load the lp file
Stu_Grp <- read.lp("C:/Users/jetan/OneDrive/Desktop/qmm2finalexam.lp")
print(Stu_Grp)
```

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

Finding Optimal Solution

```
#Group-1
get.variables(Stu_Grp)[1:15]
```

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

```
#Group-2
get.variables(Stu_Grp)[16:30]
```

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

```
#Group-3
get.variables(Stu_Grp)[31:45]
```

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

```
#Group-4
get.variables(Stu_Grp)[46:60]
```

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

Conclusion

Optimal Solution:

Group	Group 1	Group 2	Group 3	Group 4	Group 5
Student	7	2	9	4	1
	8	6	14	10	3
	11	13	15	12	5

Total Score of Each Group

