

Quantitative Management Final Exam

Kent State University
Course: **Quantitative Management**
Professor: **Dambar Uprety**

Gayathri Yenigalla – 811257871
Praneeth Simha-811252718
Shiva Chaitanya Goud Gadila-811252042

Abstract:-

This in-depth report navigates through the complexities of a refined mathematical optimization model crafted to address the formidable challenge of creating optimal student groups for collaborative projects. The primary aim is to carefully allocate students through a comprehensive assessment of their academic excellence and participation attributes, fostering a synergistic mix within each group. The model is artfully designed employing advanced linear programming techniques, going beyond mere group assembly to strategically enhance the probability of success for each group.

Goal of the Project:

The primary objective of this assignment is to construct and address a mathematical optimization model designed for a particular problem. Going beyond the superficial task of forming groups, the project aims to orchestrate the ideal amalgamation of student talents and qualities. The challenge involves organizing five groups from a pool of fifteen students, each group mandated to consist of precisely three students. The overarching aim is to execute a detailed approach that guarantees a sophisticated distribution, considering key factors such as GPA, class participation marks, and activity marks. This meticulous process is geared towards fostering an environment conducive to successful collaboration.

Data and Variables:

Central to this undertaking is the extensive dataset capturing the GPA, class participation marks, and activity marks of each of the fifteen students. This robust dataset forms the cornerstone on which the optimization model is intricately built. Introducing decision variables is a pivotal step in shaping the model, strategically symbolizing the assignment of students to particular groups. The binary essence of these variables, denoting 1 for assignment and 0 for non-assignment, introduces a nuanced layer of complexity that aligns seamlessly with the intricacies of the task.

Below are the factors/attributes of the students accountable for mixing them into different groups.

- GPA of the Student (scale of 4.0)
- Participation marks (Scale of 10)
- Activity marks (in a scale of 10)

Let us assume that below are the three factor values for the 15 students.

Student ID	NAME	GPA	PARTICIPATION MARKS	Activity
1	student 1	2.8	8.1	10
2	student2	2.4	6.2	5
3	student 3	3.8	5.7	10
4	student 4	3.7	8.8	5
5	student 5	3	5.6	10

6	student 6	3.2	9	6
7	student 7	2	5.3	7
8	student 8	2.2	7.7	7
9	student 9	2.6	7.7	6
10	student 10	3.2	7.9	5
11	student 11	3.6	8.1	9
12	student 12	3.4	8.3	10
13	student 13	2.6	5.2	8
14	student 14	2.9	7.8	7
15	student 15	2.1	7.4	5
	Average	2.9	7.25	7.3

Data Collection/Generation Process:

Above 3 factors have positive impact on success of the group project

GPA :- GPA, representing the cumulative grade point average, serves as a measure of a student's commitment and is indicative of their dedication to the successful culmination of the group project. Additionally, it mirrors their proficiency in their graduate studies, making it a crucial element influencing the project's success. The significance lies in how well it portrays the student's academic competence and overall quality.

Class Participation Marks: Class participation marks are awarded based on a student's active involvement, contribution, and engagement during class sessions. This can include asking questions, participating in discussions, and demonstrating a positive and proactive attitude towards learning. These marks reflect a student's commitment to the learning process and their ability to interact effectively in a classroom setting.

Activity Marks: Activity marks are assigned for a student's performance in various extracurricular or curricular activities, such as projects, assignments, or practical exercises. These marks assess a student's practical application of knowledge, problem-solving skills, and the effort they put into hands-on learning experiences. Activity marks contribute to the holistic evaluation of a student's skills and capabilities beyond traditional academic assessments.

Formulation:

The problem at hand aligns with the principles of "Assignment Problems" within the realm of linear programming. This is because the task involves the assignment of individuals to specific groups, necessitating the use of decision variables that can take binary values, 0 or 1. This characteristic transforms the linear programming model into an integer programming one.

The decision variables, denoting the assignment of students to groups, are structured in a way that assigns binary values (0 or 1) based on the group and student. Assuming students are labelled from S1 to S15 and groups from G1 to G5, the notation G1S1 signifies the presence of Student 1 in Group 1, with similar representations for other students and groups. A decision variable value of 1 indicates a valid assignment of the student to the group, while 0 indicates the absence of the student in that particular group.

STUDENT NAME	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

Our objective is to determine the optimal assignment of students to groups, aiming to maximize the likelihood of achieving higher GPAs within each group. Formulating this as a linear programming problem involves incorporating specific constraints:

- The decision variable values must be non-negative (≥ 0), establishing a boundary constraint.
- Each group is required to consist of precisely 3 students.
- A student is allowed membership in only one group.
- To ensure a balanced distribution of students and their qualities among groups, the average factor values across three criteria should be maintained at a minimum average level for all groups.

STUDENT	GPA	PARTICIPATION MARKS	ACTIVITY MARKS
STUDENT 1	2.8	8.1	10
STUDENT 2	2.4	6.2	5
STUDENT 3	3.8	5.7	10
STUDENT 4	3.7	8.8	5
STUDENT 4	3	5.6	10
STUDENT 6	3.2	9	6
STUDENT 7	2	5.3	7
STUDENT 8	2.2	7.7	7
STUDENT 9	2.6	7.7	6
STUDENT 10	3.2	7.9	5
STUDENT 11	3.6	8.1	9
STUDENT 12	3.4	8.3	10
STUDENT 13	2.6	5.2	8
STUDENT 14	2.9	7.8	7

STUDENT 15	2.1	7.4	5
------------	-----	-----	---

Model Building:

At the core of this document lies the meticulous development of a linear programming (LP) model, surpassing conventional group assignment frameworks. This intentionally crafted LP model strives to optimize the probability of success within each group, delicately balancing academic excellence and participatory engagement. The decision variables are intricately defined to signify the assignment of students to groups, and a set of carefully formulated constraints ensures not only a fair distribution but also adherence to the specified group size criterion. Throughout this process, an LP file is generated, leveraging the robust capabilities of the LP model to navigate and resolve the intricacies of the assignment problem with a high degree of precision and efficiency. This sophisticated approach underscores the commitment to strategic group formation and the pursuit of collaborative success in an academic setting.

Approach to Solving the Model:

Navigating the intricacies of this optimization challenge involves a nuanced application of linear programming (LP) techniques. The methodology centres on the meticulous definition of decision variables, the strategic formulation of constraints, and the judicious application of optimization methods to thoughtfully assign students to groups. Beyond mere group assembly, this approach is a purposeful orchestration, aiming for a distribution that unlocks the complete collaborative potential within each team.

At the heart of this optimization effort is the objective function, a key element seeking to maximize the likelihood of success within each group. The coefficients in this function play a crucial role, representing the weighted contributions of individual student attributes—GPA, class participation, and activity marks. This weighted approach ensures a tailored and comprehensive optimization, acknowledging the unique qualities of each student and fostering an environment where academic success and effective teamwork are intricately intertwined.

- Group Size Constraints
- Student Assignment Constraints
- Group Factor Constraints (Considering GPA, Class Participation, and Activity Marks)

/* Objective Function */

max:2.8G1S1+2.4G1S2+3.8G1S3+3.7G1S4+3.0G1S5+3.2G1S6+2.0G1S7+2.2G1S8+2.6G1S9+3.2G1S10+3.6G1S11+3.4G1S12+2.6G1S13+2.9G1S14+2.1G1S15+2.8G2S1+2.4G2S2+3.8G2S3+3.7G2S4+3.0G2S5+3.2G2S6+2.0G2S7+2.2G2S8+2.6G2S9+3.2G2S10+3.6G2S11+3.4G2S12+2.6G2S13+2.9G2S14+2.1G2S15+2.8G3S1+2.4G3S2+3.8G3S3+3.7G3S4+3.0G3S5+3.2G3S6+2.0G3S7+2.2G3S8+2.6G3S9+3.2G3S10+3.6G3S11+3.4G3S12+2.6G3S13+2.9G3S14+2.1G3S15+2.8G4S1+2.4G4S2+3.8G4S3+3.7G4S4+3.0G4S5+3.2G4S6+2.0G4S7+2.2G4S8+2.6G4S9+3.2G4S10+3.6G4S11+3.4G4S12+2.6G4S13+2.9G4S14+2.1G4S15+2.8G5S1+2.4G5S2+3.8G5S3+3.7G5S4+3.0G5S5+3.2G5S6+2.0G5S7+2.2G5S8+2.6G5S9+3.2G5S10+3.6G5S11+3.4G5S12+2.6G5S13+2.9G5S14+2.1G5S15;

/* Constraints */

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

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

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

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

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

$G1S1+G2S1+G3S1+G4S1+G5S1=1;$

$G1S2+G2S2+G3S2+G4S2+G5S2=1;$

$G1S3+G2S3+G3S3+G4S3+G5S3=1;$

$G1S4+G2S4+G3S4+G4S4+G5S4=1;$

$G1S5+G2S5+G3S5+G4S5+G5S5=1;$

$G1S6+G2S6+G3S6+G4S6+G5S6=1;$

$G1S7+G2S7+G3S7+G4S7+G5S7=1;$

$G1S8+G2S8+G3S8+G4S8+G5S8=1;$

$G1S9+G2S9+G3S9+G4S9+G5S9=1;$

$G1S10+G2S10+G3S10+G4S10+G5S10=1;$

$G1S11+G2S11+G3S11+G4S11+G5S11=1;$

$G1S12+G2S12+G3S12+G4S12+G5S12=1;$

$G1S13+G2S13+G3S13+G4S13+G5S13=1;$

$G1S14+G2S14+G3S14+G4S14+G5S14=1;$

$G1S15+G2S15+G3S15+G4S15+G5S15=1;$

$2.8G1S1+2.4G1S2+3.8G1S3+3.7G1S4+3.0G1S5+3.2G1S6+2.0G1S7+2.2G1S8+2.6G1S9+3.2G1S10+3.6G1S11+3.4G1S12+2.6G1S13+2.9G1S14+2.1G1S15 \geq 2.9;$

$2.8G2S1+2.4G2S2+3.8G2S3+3.7G2S4+3.0G2S5+3.2G2S6+2.0G2S7+2.2G2S8+2.6G2S9+3.2G2S10+3.6G2S11+3.4G2S12+2.6G2S13+2.9G2S14+2.1G2S15 \geq 2.9;$

$2.8G3S1+2.4G3S2+3.8G3S3+3.7G3S4+3.0G3S5+3.2G3S6+2.0G3S7+2.2G3S8+2.6G3S9+3.2G3S10+3.6G3S11+3.4G3S12+2.6G3S13+2.9G3S14+2.1G3S15 \geq 2.9;$

$2.8G4S1+2.4G4S2+3.8G4S3+3.7G4S4+3.0G4S5+3.2G4S6+2.0G4S7+2.2G4S8+2.6G4S9+3.2G4S10+3.6G4S11+3.4G4S12+2.6G4S13+2.9G4S14+2.1G4S15 \geq 2.9;$

$2.8G5S1+2.4G5S2+3.8G5S3+3.7G5S4+3.0G5S5+3.2G5S6+2.0G5S7+2.2G5S8+2.6G5S9+3.2G5S10+3.6G5S11+3.4G5S12+2.6G5S13+2.9G5S14+2.1G5S15 \geq 2.9;$

$8.1G1S1+6.2G1S2+5.7G1S3+8.8G1S4+5.6G1S5+9.0G1S6+5.3G1S7+7.7G1S8+7.7G1S9+7.9G1S10+8.1G1S11+8.3G1S12+5.2G1S13+7.8G1S14+7.4G1S15 \geq 7.25;$

$8.1G2S1+6.2G2S2+5.7G2S3+8.8G2S4+5.6G2S5+9.0G2S6+5.3G2S7+7.7G2S8+7.7G2S9+7.9G2S10+8.1G2S11+8.3G2S12+5.2G2S13+7.8G2S14+7.4G2S15 \geq 7.25;$

$8.1G3S1+6.2G3S2+5.7G3S3+8.8G3S4+5.6G3S5+9.0G3S6+5.3G3S7+7.7G3S8+7.7G3S9+7.9G3S10+8.1G3S11+8.3G3S12+5.2G3S13+7.8G3S14+7.4G3S15 \geq 7.25;$

$8.1G4S1+6.2G4S2+5.7G4S3+8.8G4S4+5.6G4S5+9.0G4S6+5.3G4S7+7.7G4S8+7.7G4S9+7.9G4S10+8.1G4S11+8.3G4S12+5.2G4S13+7.8G4S14+7.4G4S15 \geq 7.25;$

$8.1G5S1+6.2G5S2+5.7G5S3+8.8G5S4+5.6G5S5+9.0G5S6+5.3G5S7+7.7G5S8+7.7G5S9+7.9G5S10+8.1G5S11+8.3G5S12+5.2G5S13+7.8G5S14+7.4G5S15 \geq 7.25;$

$10G1S1+5G1S2+10G1S3+5G1S4+10G1S5+6G1S6+7G1S7+7G1S8+6G1S9+5G1S10+9G1S11+10G1S12+8G1S13+7G1S14+5G1S15 \geq 7.3;$

$10G2S1+5G2S2+10G2S3+5G2S4+10G2S5+6G2S6+7G2S7+7G2S8+6G2S9+5G2S10+9G2S11+10G2S12+8G2S13+7G2S14+5G2S15 \geq 7.3;$

$10G3S1+5G3S2+10G3S3+5G3S4+10G3S5+6G3S6+7G3S7+7G3S8+6G3S9+5G3S10+9G3S11+10G3S12+8G3S13+7G3S14+5G3S15 \geq 7.3;$

$10G4S1+5G4S2+10G4S3+5G4S4+10G4S5+6G4S6+7G4S7+7G4S8+6G4S9+5G4S10+9G4S11+10G4S12+8G4S13+7G4S14+5G4S15 \geq 7.3;$

$10G5S1+5G5S2+10G5S3+5G5S4+10G5S5+6G5S6+7G5S7+7G5S8+6G5S9+5G5S10+9G5S11+10G5S12+8G5S13+7G5S14+5G5S15 \geq 7.3;$

Findings and Conclusion:

The successful outcome of the solve(qmm) command (resulting in 0) indicates the effective resolution of the linear programming model qmm. This suggests that the optimization problem was efficiently solved, yielding an optimal solution. The value 43.5 obtained from get. Objective(qmm) represents the optimized evaluation of the objective function at this solution, highlighting the successful attainment of the targeted parameter.

The get. Constraints(qmm) command reveals coefficients associated with the constraints in the model. Ranging from 3.0 to 29.0, these coefficients signify the weights of individual constraints. With 21 constraints identified, each with its unique coefficient, these values encapsulate the nuanced considerations and limitations guiding the optimization process.

The output

1000000010000100000000110000100010000000001001000101000.100000001010000010000 from
get.variable(gmm)

Based the Linear Programming solution the optimal distribution of the students will be:

GROUPS	STUDENTS
GROUP 1	Student 1, Student 9 , Student 14
GROUP 2	Student 7, Student 8, Student 13
GROUP 3	Student 2, Student12 , Student15
GROUP 4	Student 4, Student 6, Student 10
GROUP 5	Student 3, Student 5 , Student 11

In conclusion, this project effectively used advanced linear programming to create well-balanced student groups, considering factors like GPA and participation. The success showcases the power of binary integer programming in addressing assignment problems and goes beyond conventional group formation.

The model not only offers a strong solution for student group formation but also demonstrates the broader applicability of binary integer programming in diverse optimization challenges. The commitment to strategic group formation is evident, resulting in a thoughtful and collaborative environment.

Reflecting on the outcomes, the model successfully met project goals, creating balanced groups conducive to successful collaboration. This project underscores the effectiveness of quantitative management in real-world problem-solving and its crucial role in decision-making in academic settings and beyond.

Through strategic orchestration of student talents, this project contributes to the broader discourse on optimization in collaborative environments. As the academic landscape evolves, leveraging quantitative management approaches remains vital for informed decision-making and continued pursuit of excellence.

References:

Massachusetts Institute of Technology:-<https://web.mit.edu/lpsolve/doc/>

Google or tools :- https://developers.google.com/optimization/lp/lp_example

Maplesoft:-

<https://www.maplesoft.com/support/help/maple/view.aspx?path=Optimization%2FLPSolve>

linear Programming Textbook

Academic Papers on Optimization

Quantitative Management Principles