**Case Study 2:**

**Museum of Fine Arts Houston**

Acacia Johnson

Tarleton State University

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Dr. Triss Ashton

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The Museum of Fine Arts in Houston (MFAH) has decided to host an exhibit for “up-and-coming modern artists.” A sponsor by the name of Joshua Allen has agreed to fund the exhibit using his SERP money and any additional monies. The budget proposed is at least $1,450,000 and should be used to educate the public in different artistic styles. Allen and Per Knutås, the assigned MFAH representative, each have their own respective requirements for the exhibit.

**Methodology**

The data collected focuses on artists applying to be in the MFAH exhibit. Each piece of artwork includes data about the artist, piece name, type, subtype, gender, and price of each entry. ‘Type’ describes whether the work is a sculpture, painting, drawing, or collage, while the subtype describes more unique characteristics. These distinctions are needed to properly meet each requirement by Allen and Per Knutås. All models and analyses were developed using Python, primarily utilizing the PuLP, Pandas, Numpy, and GLPK libraries. From this, both the mathematical and optimization models are created.

Based on the data given, the mathematical model compares type, subtype, gender, and price to meet the specified constraints. There are 15 individual requirements between Allen and Per Knutås that mention artistic vision and personal relationships. Those requirements are accounted for in each scenario and detailed within the Python code. The total costs is calculated by summing up the price of each selected artwork.

**Results**

Listed below are three different and separate scenarios. Each scenario uses the base constraints as described in the methodology section in addition to new objective functions and constraints. The result of one scenario has no bearing or influence on another, but serves as a stepping stone to more complex constraints. This provides the client with the tools necessary to construct an appropriate exhibit for all parties involved.

**Scenario A – Maximize the Number of Pieces Seen**

This scenario focuses on maximizing the total number of art pieces selected with a budget of $4 million. All art pieces displayed should meet the requirements set by Joshua Allen and Per Knutås. The Python model created for the scenario features a binary integer programming simulation. The solution is solved using the PuLP package and GLPK solver. The optimized solution includes 15 art pieces at a total cost of $3,950,000. This leaves an additional $50,000 in unused budget. The selected pieces include:

* *The Great Equalizer*
* *Julia Fractal*
* *Squandered Element*
* *Serenity*
* *Calm Before the Storm*
* *The Abyss*
* *Harley*
* *Reflection*
* *Caleb on Expressionism*
* *Wisdom*
* *Study of a Fruit Bowl*
* *All that Glitters*
* *The Launch*
* *Dock Nets*
* *Past & Future Dreams Come True*

In addition to meeting the base constraints, the selected pieces feature all four of Joshua Allen's works, a painting in each style, and a focus towards gender exclusivity and environmentalism. If MFAH were to adjust any constraints, they need to heed the six binding (mandatory) constraints. The budget, number of collages, painting styles, wire-mesh to computer-generated ratio, painting to non-painting ratio, and the mandatory artist inclusions can drastically affect the outcome. There is more flexibility within the maximum number of sculptures or wall art categories than the binding constraints.

**Scenario B – Minimize the Costs for 20 Displayed Pieces**

This scenario attempts to minimize the total cost of the exhibit. All art pieces displayed should meet the requirements set by Joshua Allen and Per Knutås. In addition, there is a new constraint requiring at least 20 selected art pieces. The Python model created for this scenario features a binary integer programming simulation focused on capital budgeting. The solution is solved using the PuLP package and GLPK solver. The optimized solution includes 20 art pieces at a total cost of $5,600,000. In comparison to Scenario A, there is a $1,600,000 increase for 5 extra art pieces that meet all requirements. The selected pieces include:

* *Burden\**
* *The Great Equalizer*
* *Julia Fractal*
* *Periodic Table\**
* *Squandered Element*
* *Serenity*
* *Calm Before the Storm*
* *The Abyss*
* *Morning light\**
* *Harley*
* *Reflection*
* *Caleb on Expressionism*
* *Wisdom*
* *Keepers of the Plains\**
* *Study of a Violin\**
* *Study of a Fruit Bowl*
* *All that Glitters*
* *The Launch*
* *Dock Nets*
* *Past & Future Dreams Come True*

*\* - Added pieces in comparison to Scenario A*

In addition to meeting the base constraints, the selected pieces feature all four of Joshua Allen's works; a mixture of sculptures, drawings, and paintings; Erica Huddleston’s Julia Fractal and Periodic Tables; and HA Schult’s Squandered Element. If MFAH were to adjust any constraints, they need to heed the two binding (mandatory) constraints: the minimum art piece count and required painting styles. Unlike Scenario A, the budget is not binding and is adjustable.

**Scenario C – Minimize Cost for Exactly 20 Pieces, Including All Erica’s Works**

This scenario attempts to minimize the total cost of the exhibit. All art pieces displayed should meet the requirements set by Joshua Allen and Per Knutås. In addition, there is a new constraint requiring at least 20 selected art pieces *and* all of Erica Huddleston’s work. The Python model created for this scenario builds upon Scenario B by requiring an entire artist’s discography. The solution is solved using the PuLP package and GLPK solver. The optimized solution includes 20 art pieces at a total cost of $5,800,000. In comparison to Scenario A, there is a $1,800,000 increase for 5 extra art pieces that meet all requirements. The selected pieces include:

* *Burden\**
* *The Great Equalizer*
* *Julia Fractal*
* *Periodic Table\**
* *Domestication\**
* *Innocence\**
* *Squandered Element*
* *Serenity*
* *Calm Before the Storm*
* *The Abyss*
* *Morning light\**
* *Harley*
* *Reflection*
* *Caleb on Expressionism*
* *Wisdom*
* *Study of a Violin\**
* *All that Glitters*
* *The Launch*
* *Dock Nets*
* *Past & Future Dreams Come True*

*\* - Added pieces in comparison to Scenario A*

In addition to meeting the base constraints, the selected pieces feature all four of Joshua Allen's works; a mixture of sculptures, drawings, and paintings; Erica Huddleston’s Julia Fractal and Periodic Tables; and wire-mesh to computer-generated ratio. If MFAH were to adjust any constraints, they need to heed the aforementioned and new binding (mandatory) constraints. Unlike Scenario A, the budget is not binding and is adjustable.

**Discussion and Conclusion**

For each scenario, there is a benefit and disadvantage to the exhibit created. Scenario A focuses on minimizing the $4 million budget. The 15 different art pieces selected by the model provide a rudimentary and basic approach to the work that can be displayed. For example, the constraints limited alternative pieces such as Erica Huddleston's and removed the opportunity of the public seeing them. Despite being cost-efficient, the limitation of exposure harms the public.

Scenario B Removes the spending budget and requires a minimum of 20 art pieces. There is still an overarching theme of minimizing total costs, but a greater selection of artwork to display serves as a trade-off. There is a significant price increase from Scenario A since five additional pieces are selected. This model not only meets the minimum requirements of Joshua Allen and Per Knutås but expands upon the pre-established themes. This is a great middle ground for minimizing cost and having a robust exhibit.

Scenario C is the most extreme option, with requiring exactly 20 pieces and all of Erica Huddleston’s works. The total cost of this model is almost $2,000,000 more than Scenario A. Realistically, if cost is not a constraint, the museum should follow the recommended art pieces in this model. The themes represented in this exhibit are politically and artistically complete while indicating the public's influence on local artwork. MFAH should select this option if they seek to represent and showcase the community that surrounds them.

Alternative optimizations could come in the form of more art pieces or relaxing the existing constraints. If there is not a consensus of which pieces to display, increase the total number by increments of five. This allows more artists to be shown to the public. The other solution is to change Allens or Per Knutås requests. For example, the constraints requiring a minimum of each painting style can be removed. This removes diversity in the exhibit but increases freedom in what pieces are selected. These choices in selection can hinder or improve the quality of the exhibit. It is up to the museum director to make those decisions.

**Programming Scripts**

**Scenario A**



**Scenario B**



**Scenario C**

