Miguel Uses Multiple Criteria to Choose a College

Introduction

In the course of life, we all face important decisions. Miguel has made the important decision to pursue a college education. He applied to a number of colleges and was accepted at four: State University and Podunk University, a small school where he was sure to receive a lot of academic support. Miguel was also considering a career in electronics or electrical engineering, and was accepted at two schools with strong engineering reputations: I.Q.U. and High Polytechnic Institute. Miguel and Chloe realized that there are many different issues to be considered in making this decision. They also realized that the issues of interest to Miguel and their relative importance are not the same as those for Chloe.

In this activity, you will read about a systematic process called **M**ulti-**A**ttribute **U**tility **T**heory (MAUT) that helped Miguel and Chloe make an informed choice about the college to attend. At the same time, you will apply this process to your own search for a preferred college. *Whenever you are directed to perform a step in your own choice of a college, those directions will appear in italics.* The steps in this process are:

- Generate a list containing general attributes that are important to you in choosing a college. These attributes will be broad in nature and will be based on objective and subjective goals.
- Specify at least one measure for each attribute, and specify a reasonable scale for each measure.
- Create a list of colleges at which you anticipate being accepted or have been accepted.
- For each college, collect the data for each measure.
- Rescale each measure to "Common Units" from 0 to 1, with 0 the worst and 1 the best.
- Ask a classmate to interview you in order to determine the relative importance of each measure. With your classmate's help, rank order the measures, assign points from 0 to 100 to each measure, and calculate a proportional weight between 0 and 1 for each measure.
- Calculate the total weighted score for each college. These weights will yield a ranking of the colleges, allowing you to identify the best college for you.
- Lastly, review the results to understand the strengths and weaknesses of your top alternatives and to finalize your decision.

Part 1: Specify Attributes and Measures

With Chloe's help, Miguel decided that ***academics, cost, location,*** and ***social life*** are the factors (attributes) most critical in his choice of a school.

Generate a list of broad attributes that are important to YOU in choosing your college. You may choose as many attributes as you desire. Be aware that more attributes will require more computations. When you have created your own list of attributes, compare your list with that of a partner. How are your lists similar? How are they different?

Next, Miguel and Chloe took his list of four attributes and specified 2 or 3 measures for each attribute.

Attributes	Measures
Academics:	1) Average total SAT Score of last year's freshman class
	2) *US News and World Report* ranking
Cost:	3) Living Expenses
	4) Tuition
Location:	5) Average Daily High Temperature
	6) Proximity to Home
Social Life:	7) Athletics
	8) Reputation
	9) Size

Choose at least one measure for each of your attributes. Try to limit yourself to no more than three measures per attribute. In order to ensure a manageable number of choices, narrow your selection of colleges to no more than five. If you are creating a hypothetical list of schools, include in your set only schools to which you might apply and have a realistic chance of being accepted. Include at least two schools that you are absolutely sure you will be accepted at. Your list should represent the diversity of your preferences. For example, it may include a small college and large university, or a nearby school and one far from home.

Scale Each Measure. The next task that Miguel and Chloe faced was choosing an appropriate scale for each of nine measures Miguel identified above. They also realized that some of the measures, such as average SAT score, have a natural scale (the combined score), while other measures, such as athletics, require the construction of a scale. Furthermore, some of the measures will be continuous (SAT scores), while others will use different categories. For example, Miguel and Chloe developed a four-category scale for athletics:

1. Top ten ranking in men's basketball or football or women's volleyball or basketball in the past two years.
2. Top twenty-five ranking in any two of the above sports.
3. Division I status.
4. Other.
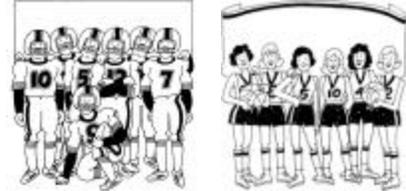
They also realized that the range of each scale is important. For example, the theoretical range of the average combined SAT score is 400-1600, but in actuality, Miguel and Chloe decided that a range of 900-1400 is much more realistic. The scale range and type that they used for each measure are given in the following table:

Table 1: Types and Ranges of Measures

Measure	Range of Scale	Type
Average Combined SAT Score	900-1400 (realistic)	Continuous-natural
US News & World Report Rank	1. Top 25 2. 26 - 100 3. 101 - 250 4. Unranked	Categorical-constructed
Living Expenses	$6,000 - $12,000 (realistic)	Continuous-natural
Tuition & Fees	$5,000 - $20,000 (realistic)	Continuous-natural
Average Daily High Temperature	50° to 70° F.	Continuous-natural
Proximity to Home	1. Commuting (0-100 mi.) 2. Within 4-hr. drive (101-250 mi.) 3. Within day's drive (251-500 mi.) 4. Far (0ver 500 mi.)	Categorical-constructed
Athletics	1. Top-ten in one sport 2. Top 25 in two sports 3. Division I 4. Other	Categorical-constructed
Reputation	1. Seriously academic 2. Balanced academics and social life 3. Party school	Categorical-constructed
Size	1. Under 3,000 2. 3,001-6,000 3. 6,001-12,000 4. Over 12,000	Categorical-constructed

Create a table showing a scale or range for each of the measures you listed. Remember that you will need to construct a scale for any measure that does not have a natural one. Label each scale as natural or constructed.

Collect Data. After scaling each measure, Miguel and Chloe collected these data.

Table 2: Measures for Miguel's Four Schools

Measure	Podunk U.	State U.	I.Q. U.	High Polytech
SAT Score	1050	1000	1300	1320
US News	Unranked	200	30	20
Living Expenses	$9,000	$7,000	$9,000	$12,000
Tuition	$18,000	$6,000	$8,000	$12,000
Avg. Daily High	55° F.	58° F.	62° F.	68° F.
Nearness to Home	4	1	3	4
Athletics	4	1	3	3
Reputation	2	3	1	1
Size	1	4	3	2

Collect similar data and construct a table for your choice of colleges. Sources for these data can be the Internet, a commercial college selection text or your school's college counselors.

Rescale to Common Units. Once Miguel and Chloe collected the data, Chloe reminded Miguel that if they compared the data in its current form, it would be like comparing apples to oranges. They decided to convert the data to "common units." This means assigning a value of 1 to the best value and a value of 0 to the worst value in the range of each measure. (The word "utility" in MAUT refers to the process of scaling to a common unit that ranges from 0 to 1.) For intermediate values, if the measure has a continuous scale, the common unit value may be assigned proportionally. For example, the average combined SAT score at Podunk U. was 1050. The range for this measure was 900-1400, so 900 converted to 0, 1400 to 1, and the proportional value for Podunk U. was (1050-900)/(1400-900)=0.3.

On the other hand, for categorical measures, after assigning the best value a common unit of 1 and the worst value a common unit of 0, Miguel and Chloe had to decide how to apportion the common units. In some cases, apportionment might be proportional, while in other cases it might not. They decided to use proportional common units for every categorical measure except *US News & World Report* ranking.

Some of the results of Miguel's and Chloe's rescaling to common units appear in the following table. Fill in the rescaled common units for each of the blanks in the table.

Table 3: Common Units

MEASURE	Podunk U.	State U.	I.Q. U.	High Polytech
SAT Score	.3			
US News	0	.25	.75	1
Living Expenses	.5			0
Tuition		.93		
Avg. Daily High	.25			
Nearness to Home			.67	
Athletics			.33	.33
Reputation	1	0		
Size	0	1		

Complete a similar rescaling to common units table for the real data you collected for your own choice of colleges.

Part 2: Conduct Interview to Calculate Weights

Next, Miguel and Chloe assigned weights to each of the measures to reflect the relative importance Miguel attaches to each of them. They decided Chloe would interview Miguel. She made observations to ensure that Miguel understood the measures he chose and the effects of the weights he assigned to each of them. They created the following table.

Table 4: Ranking and Weighting Measures

Attributes	Measure	Least Preferred	Most Preferred	Rank Order	Points (0-100)	Calculate Weight (Points/Sum)
Academics	SAT Score	1100	1500			
	US News	Below 101	Top 25			
Cost	Living Expenses	$12,000	$6,000			
	Tuition	$20,000	$4,000			
Location	Avg. Daily High	50° F	70° F			
	Nearness to Home	Far	Very Close			
Social Life	Athletics	Other	Top Ten			
	Undergrad Pop.	Over 12,000	Under 3,000			
	Image	Party	Balanced			
				Sum =		

Using the data for your personal choice of a college, create a table similar to Table 4. Be sure to include your most preferred and least preferred values for each of your measures. As Chloe interviews Miguel, use the same process with a partner to rank your measures and assign points to them.

Chloe: "We have some measures and their ranges for making a decision about your college preference. Focus first on the column of least preferred values. For which one of the measures would it be most important to you to increase from the least preferred value to its most preferred value? For example, is it more important to you to move the SAT score from 1100 to 1500 or reduce tuition from $20,000 to $4,000?"

Miguel: "Lower the tuition!"

Chloe: "Are you sure that lowering the tuition to $4,000 is the most important improvement in the whole list?"

Miguel: " Yes, so I think we should rank Tuition number 1."

Chloe: "Miguel, what would be the next most important measure to move from least to most preferred?

Miguel: "*U.S. News and World Report* ranking is important. So let's rank that second, and SAT score third."

The next goal is to subjectively assign points from 0 to 100 for each measure based upon the rank order, where rank order is the relative importance of each measure to you.

Chloe: "Start by assigning 100 points to the Tuition range, which you ranked first. Now, you ranked the U. S. News and World Report rating second. How important is this rating from worst to best, compared to reducing the cost of tuition from $20,000 to $4,000? If it's close, you should use a number close to 100."

Miguel: "I think it's about 90% as important, so let's use 90 points for that one, and SAT scores are almost as important, so we'll use 88 points for that range."

Table 5 on the next page contains the points Miguel assigned to each of his measures. Assign points to your own measures based on the rank order you placed them in and the relative importance to you of having a value closer to the most preferred value than the least.

Table 5: Miguel's Rank and Point Assignment

Attributes	Measure	Least Preferred	Most Preferred	Rank Order	Points (0-100)	Calculate Weight (Points/Sum)
Academics	SAT Score	1100	1500	3	88	
	US News	Below 101	Top 25	2	90	
Cost	Living Expenses	$12,000	$6,000	4	70	
	Tuition	$20,000	$4,000	1	100	
Location	Avg. Daily High	50° F	70° F	8	20	
	Nearness to Home	Far	Very Close	6	50	
Social Life	Athletics	Other	Top Ten	5	60	
	Undergrad Pop.	Over 12,000	Under 3,000	9	10	
	Image	Party	Balanced	6	50	
				Sum =	538	

Chloe: "Miguel, what did you get for the total number of points for all your measures? Once you have the point total, you'll need to divide the points for each measure by this total to get the weight."
Miguel: "I got 538 total points, and I recorded the weights in Table 6."

Using the same process, compute the weights for each of your measures. Check to see if the sum of the weights is close to 1.

Chloe: "Miguel, what is the total weight for each attribute?
Miguel: "I get a total of .33 for academics, .32 for cost, .13 for location and .22 for social life."
Chloe: "Which attribute has the greatest weight assigned to it?"
Miguel: "It looks like academics, with .33."
Chloe: "Are there attributes with similar weights?
Miguel: "It looks like academics and cost are almost the same.
Chloe: "Are these the attributes you feel are the most important criteria for choosing a college, and do you think they're about the same in importance?"
Miguel: "I didn't realize I placed so much importance on academics."
Chloe: "What did you expect to happen?"
Miguel: "Well, I thought the social life would be at the top of the list!"
Chloe: "Well, you gave athletics 60 points, image 50 points, and undergraduate population only 10 points. Do you want to change anything?"
Miguel: "No, I really think academics and cost are most important."

Total the weights of the measures within each of your attributes. Are you satisfied with your totals?
Discuss the following questions with your classmates:
1. *Which of your attributes has the greatest weight?*
2. *Is this the attribute that you feel is the most important criteria for choosing a college? If not, explain why your results are different than you expected?*
3. *Is the number of measures an indication of importance to an attribute? Explain.*
4. *Did the attribute with the most measures receive the highest points in your hierarchy? Explain whether you agree or disagree with this particular attribute being the most important criteria for choosing a college?*
5. *Are there any measures or attributes you omitted that you now think should have been included? If so, revise your list and start over again. The process should move quickly since many of your responses will be close to what you answered before.*

Part 3: Calculate Total Scores

Miguel and Chloe determined which school is the best choice for him to attend. They used the data from Table 3, where common units were computed, and the weights calculated in the last column of Table 5. In Table 6 below, Miguel calculated the product of the weight (W) and the corresponding common unit (CU) from Table 3: Score=W x CU. Then by totaling the points for each college in Table 6, Miguel learned which of his college choices best suits his needs.

Table 6: Calculating the Total Scores of Miguel's Schools

Measure	Weight	Podunk U.	State U.	I.Q. U.	High Polytech
SAT Score	.16	.16 x .3 = .048	.016	.128	.1344
US News	.17	0	.0425	.1275	.17
Living Expenses	.13	.065	.1079	.065	0
Tuition	.19	.0247	.1767	.152	.1007
Avg. Daily High	.04	.01	.016	.024	.036
Nearness to Home	.09	.09	0	.0594	.09
Athletics	.11	0	.11	.0374	.0374
Undergrad Pop.	.02	.02	0	.01	.01
Image	.09	0	.09	.0594	.0306
TOTAL SCORE	1.00	.2577	.5591	.6627	.6091

Based on the table above Miguel has decided to attend I.Q. University.

Use this same procedure with your data to convert your common units and weights to a score for each measure. Then obtain a total score for each of your colleges. Based on your scores, which college should you choose?

Headlines From the World of Operations Research

Spanish Government

Multi-criteria decision-making used to make hundreds of IT equipment and IT service purchase decisions.

BC Hydro

Key executives in multi-billion dollar corporation are interviewed to determine their fundamental objectives and tradeoffs amongst objectives. MAUT was to be used to make a series of strategic decisions regarding power plant capacity, construction of transmission lines, and negotiation of power agreements.

US Army: Air Defense

MAUT used to rank order alternate weapons mixes for the forward area air defense (FAAD) system.

The Mathematics of Decision-Making in Industry and Government
A Public Awareness Committee (PAC) Project of INFORMS