Lesson 10 – Weighted Objectives Table and Optimum Mix Sheet

1. Background Narrative

Engineers often have to consider many different criteria when making choices about materials or other design variables. The criteria should include technical effectiveness of a material or process, cost, and social and environmental consequences. Taken individually, these criteria could lead to very different choices. A weighted objectives analysis is one way to use a rational basis for incorporating the multiple criteria into the decision.

For our unit problem, students will have to analyze their particular problem scenario to determine the characteristics to base their weighted objectives table on. The three problem scenarios will be introduced in this lesson. For example, the groups with the water park scenario may choose the infiltration rate as a characteristic to look at. They will rate the three porous concrete recipes on how well water infiltrates.

Students will learn how to create and analyze a weighted objectives table to make an objective decision regarding the best recipe for the type of concrete they are using.

2. Performance Objectives

- Students will be able to define a list of criteria that are important to consider when analyzing their concrete choices.
- Students will be able to analyze data and will be able to determine the most suitable concrete recipe.
- Students will be able to identify needs and opportunities for technical solutions from an investigation of situations of social interest.

3. Standards:

- NYS: 1.1, 1.2, 1.3, 5.1, 6.6, 7.1
- US Math: 5.3
- US Tech: 1.3, 2.1, 2.2, 3.2, 4.3

4. Resources

- Teacher's guide – Weighted Objectives Table Example
- Weighted Objectives Table Worksheet
- Samples of broken cylinders for students to observe, if desired

5. Vocabulary

Weighted Objectives Table	**Attribute**
Client	

6. Instruction plan

1. Introduction and brainstorm (5-8 minutes)

Remind students about the results of their strength and infiltration testing – which aggregates are strongest or have the highest infiltration rate? Ask them – do we choose these? Are these the only important factors? No, we need to think about other criteria as well.

Brainstorm other criteria as a class. Good criteria to use include aesthetics (does it look nice?), texture (smooth/rough), feel (crumbly?), availability (how much of the aggregate material do we have on hand?), appropriateness (is this an appropriate material?), cost (is it cost effective?). They may come up with additional ideas, write them all down. *Don't erase!*

2. Weighted Objectives Table Lesson (25 minutes)

How do we make a decision that takes into account all these criteria that are important to us?

Introduce students to what a weighted objectives table is – a tool for multiple criteria decision making.

Use an example of something the students are interested in. For example, superheroes.

1. Draw a blank weighted objectives table on the board (or overhead).
2. Ask the students what superhero they think is best – write answers on board in a list. Let them pick four or five of their favorites. Tell them we will use the weighted objectives table to mathematically "prove" who really is the greatest.
3. List attributes of a great superhero, for example strength, fighting abilities, weaknesses, and attractiveness of tights. As a class, decide which attributes are the most important – choose 5 attributes, and then rank them 1 through 5, with 5 being most important, 1 being least important.
4. Using an overhead or the board, go through the weighted objectives table with the class in determining the best superhero.
    - Write superhero names in appropriate places.
    - Write criteria (attributes) in appropriate places.
    - Assign weights to the different attributes. The weights they apply to the various attributes could sum to 1 (or you could use % and have them add to 100), although this is not critical. Give higher weights to more important attributes.
    - Score each attribute for each superhero. The scores for each attribute should be on a scale from 1-10 (10 being best, 1 being worst).
    - Calculate the rank for each attribute for each superhero (rank = score x weight).
    - Sum the ranks for each superhero – the highest rank is the best choice.

Ask the students if they think they can use this analysis to find the best aggregates for their project.

The lesson can be ended at this point. Begin the next class with a brief review.

3. Introduce the Problem Scenarios (15 minutes)

Remind the students about the **Unit Problem Statement**
"You are working for a concrete company and have many clients. Different types of concrete are better suited for various applications. It is your job to evaluate the clients' needs and determine the optimum concrete for the application."

Now that we have a tool to use in determining the best concrete to solve a specific client's needs, it's time for us to put it to the test. Three different clients have contacted us and are looking for a concrete product to solve their problems. Explain these three to the students briefly.

1. Walmart is coming to town. They are going to be building their new store out of concrete and would like to make it as green as possible.

2. There is going to be a new water park in the North Country. Splash City will need a whole system of walkways between attractions. The walkways will be made of concrete and safety is important.

3. The town is getting a new skate park. The ramps, boxes, ledges, and floors need to be smooth for speed, and strong for durability. Concrete will be used for this park.

DO NOT MENTION WHAT TYPE OF CONCRETE SHOULD BE USED FOR EACH APPLICATION!!

4. Use the Weighted Objectives Table to determine the best recipe (20 minutes).

This can be done in small groups or as a whole class activity – if done in groups, make sure all groups use the same list of criteria, then come together at the end of class to summarize all scores and get a final (can make a big chart on board and have each group write in their numbers, then have someone add up)

1. Revisit the list of criteria from the brainstorm. Guide the students to reduce the list to 4 or 5 items that are most important – from the teacher's perspective, it's very important to include "availability" as an important criteria, to make sure that we have enough of the chosen aggregate! Appropriateness and Cost are also important parts of the 8^{th} grade curriculum.
2. Distribute blank weighted objectives tables – either to individuals or in groups. .
3. First have students list the recipes across the top, and the criteria down the left side. Then they should weight the criteria, in order of importance (higher weight number means more important). Again, the numbers here are arbitrary, as long as the higher numbers are for the more important criteria.
4. Students should then evaluate each recipe for each criterion. Students should use the graphs they generated from their test cylinder data, in addition to what they know about the different recipes, to help them determine rankings for some

different attributes (strength, aesthetics). They may need help for some criteria (e.g., availability). Samples of broken cylinders may also be helpful.

5. Multiply weight x rank for each aggregate/criteria combination, enter the value in each space provided. Sum the ranks for each recipe, to get a final score.
6. Teachers should visit groups to answer questions.

5. Closure: Refocus the students on the problem solving method. Indicate where they are in overall problem solving. You just chose the best concrete recipe! What's next? We will have provide our clients with samples of the concrete. That means that we will have to fabricate some samples.

Weighted Objectives Table - Example

Attributes	Weight	Recipe 1		Recipe 2		Recipe 3					
Strength	.4	9	3.6	7	2.8	5	2				
Texture	.25	3	.75	7	1.75	9	2.25				
Appearance	.25	8	2	9	2.25	5	1.25				
Availability	.1	6	.6	5	.5	3	.3				
Total		6.95		7.3		5.8					

For this example (arbitrary values in table):

Criteria:

1. Strength: This is the strength of the concrete cylinder, greater strength = higher score
2. Texture: This is the texture of the concrete cylinder, better texture = higher score
3. Appearance: This is the appearance of the cured concrete, more attractive = higher score
4. Availability: This rates the availability of the aggregates, more available = higher score

Each criterion is weighted a certain amount, depending on its importance relative to the others listed. For example Strength is weighted 0.4 as can be seen in the table above. These weightings are chosen based on the engineer's decision regarding the most important criterion. The weight should add up to 10, or 100.

Each aggregate is then rated on a scale from 1 to 10, where 10 is the highest, for each criterion. These numbers are entered in the grid, where the criterion and the aggregate intersect.

To find the total score for each recipe, the score for each criterion is multiplied by the weight factor, and these are then added together for the aggregate. For Recipe 1:
$Total = (.40)(9) + (.25)(3) + (.25)(8) + (.10)(6) = 6.95$

The highest scored recipe is the one that will be used.

Example: The best recipe is #2 with a score of 7.3.
Therefore, when making the client sample, recipe #2 should be used.

Weighted Objectives Table

Your Name: _____ **Date: _____**

Teammates: _____

_____

_____

Attributes	Weight											
Total												

Checklist of Student Progress for Weighted Objectives Table **Student: _____**		
Learning Goals	**Checklist**	**Observation**
Identify important criteria • List criteria • Make decisions about which ones to pick • Some sort of logical elimination skill		
Developing the table • Able to label the table appropriately • Able to rank criteria • Able to compute weights for each criteria		
Applying understandings • Able assign different values to the criteria for each energy system • Able to calculate score • Analyze all alternatives and deduce from the table which is the best system based on all chosen criteria		

Name: _____ **Date:** _____

Homework: Weighted Objectives Table

1. **What is a Weighted Objectives Table? Why do we use it?**

2. **What are five characteristics that are important for evaluating concrete?**
   - _____
   - _____
   - _____
   - _____
   - _____