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| **Title: Van Halen and Brown M&Ms; The Scientific Method and Nature of Science.** |
| **Introduction:**  This teaching unit is a variant of the Lady Tasting Tea case study. The main teaching goal is to design an experiment, carry out the experiment and analyze the results. One advantage of this activity is that it can be done in a classroom (PBL) or computer room.  There are also optional subunits associated with this teaching unit. These are listed here with main learning goals:  Optional subunit i) Title: **Experimental Design and Hypothesis testing in the Real World.**  Goal: Understanding how limitations in resources, time and technology limits the experimental design that is achievable, and how initial conclusions might change with revision of hypothesis and retesting, as well as increased resources or improved technology.  Incorporation: This subunit begins after the end of the main teaching unit.  Optional subunit ii) Title: **Statistical Analysis and Significance.**  Goal: Application of their understanding of statistical significance to experimental design and analysis of results.  Incorporation: This subunit replaces some of the qualitative and intuitive discussion on experimental design with a quantitative understanding of significance, and teaches the use of Excel in order to calculate experimental significance (using a Chi Square Test) and record/manipulate data. As you follow the activity sheet (Student\_FoodScientistHershey), this subunit should be used after discussing the hypothesis, but before discussing the Experimental Design.  Optional subunit iii) Title: **Philosophy of Science. Objective vs. situated science.**  Goal: Understanding the difference in Scientific Practice as described by “The Scientific Method” compared to Kuhn’s “Scientific Revolution” as it pertains to this example.  Incorporation. This subunit is applied before the main unit. Here, the main unit is used as an illustration of The Scientific Method in practice, then after discussion of Kuhnian paradigms, the main unit is again used as an illustration of the importance of paradigms.  **Core Teaching Unit: Van Halen & Brown M&Ms**  **Learning goals of core teaching unit**:  1. Formulating a hypothesis and null hypothesis.  2. Designing an experiment based on a stated hypothesis.  3. Executing their experimental design.  4. Interpreting experimental results and presenting conclusions. |
| **Instructions for the faculty**:  This activity should be used early in the course. It is meant to be used in conjunction with discussions on Nature of Science. It can be implemented in as little as ~1.5 hr up to 2 class sessions (approximately 4 hr).  From the developer: *This activity was originally used in the 2nd day of the Citizen Science program; in the class (PBL) section of the Wet Lab Module. It was used to reinforce concepts of experimental design also practiced in laboratory experiments, and to illustrate scientific philosophy concepts (optional subunit iii). It was then recalled later during the Computing Module; when we discussed statistical tests.*  *I found that one of the benefits of this teaching unit was that it helped bridge the engage student’s affective domains early in the course; allowing for stronger student ‘buy-in’ during later activities and more effective group-work.*  **You will need**: 1 or 2 large bags (42 oz) of regular M&Ms. 4-5 Blindfolds.  ASSUMED PRIOR KNOWLEDGE: This activity assumes no prior knowledge of science, and should be performed early in a scientific literacy course to illustrate early lessons on The Nature of Science.  Students gain necessary prior knowledge from reading on hypothesis formation before initiating this activity (File name: *Student\_Onhypothesisbasics*). These readings can also be assigned in class or discussed before beginning the activity.  This activity can be used in the earliest days of the course. It can be implemented in as little as 1.5 hr. If you do two of the three sub-teaching units, this can be taught in up to 2 class sessions (1 whole day).  FACULTY SPECIALIZED KNOWLEDGE. For this Core Teaching Unit, faculty should familiarize themselves with definitions of Hypothesis, Null Hypothesis, Experimental Design, Predicted Results, Chance Outcomes, and Statistical Significance. Faculty should also familiarize themselves with The Scientific Method. |
| **Intended outcomes**:  Students understand how to ‘do science’; design an experiment, form hypothesis, execute experiments, analyze results, and present conclusions. |
| **Assessment**:  Handouts and Activity Instructions for experiment/activity.  Observation on group-work behavior. |
| **Activities**:  **Day 1. 2-2.5 hours**   1. **Inititial Observation:** Introduce Van Halen via Youtube (I recommend “Running With the Devil”). Encourage students to show their best air-guitar. 2. Introduction to Van Halen contract. Main points of the story provided in *Faculty\_IntroduceVanHalenContract*. Distribute or show relevant page of contract (*Student\_VanHalenPage1, Student\_VanHalen1982.gif*). Point out how this can be considered the initial observation before the experiment. 3. **Hypothesis.** Give students the case-study and handout (Student\_FoodScientistHershey). Go over instructions. If you have not gone over hypothesis/null hypothesis, now is a good time to do so. (*Student\_Onhypothesisbasics)* 4. Think Pair Share: Ask students to write down their hypothesis/null hypothesis, then share with a partner, then discuss and revise (Should take 5 mins). Answers are in *Faculty\_FoodScientistHershey\_ANSWERKEY*. 5. Class Discussion. Ask for all hypothesis, and write them on the board. Discuss characteristics of a good hypothesis, then discuss which hypothesis they should test as a class. 6. If you would like to use this activity to discuss The Scientific Method and Philosophy of Science, please use instructions from the **subunit III: Philosophy of Science. Objective vs. situated science** at this point. 7. **Experimental Design.** Put out the giant bag of M&Ms and blindfolds. Divide the class into 4 groups of 5 (minimum group size is 3 students). Explain that overall activity is that they design then conduct an experiment to test their hypothesis. 8. Start with a class discussion on the simple question they should ask the subject after they have eaten the MnM. Then, when they have all agreed that the questions hould be “Was the MnM you just ate brown?” (*Faculty\_FoodScientistHershey\_ANSWERKEY*.), 9. Instruct students to discuss questions on Statistical significance in Activity Sheet. (Student\_FoodScientistHershey). (This should take 10-15 minutes). You can also have a discussion on the importance of first establishing the statistical significance before designing the experiment, as it will inform experimental design. While groups are working, walk around the room and listen in on their discussions of experimental design and monitor the contribution of different group members. Try to guide groups to the correct experiment (as detailed in the Faculty\_FoodScientistHershey\_ANSWERKEY) by asking questions of other points to consider. They should also know they are expected to hand in one handout per group at the end of class for assessment. 10. If you would like to use this activity to discuss statistics and significance, please follow instructions for **subunit II: Statistical Analysis and Significance** here. Else, I think it is sufficient to discuss in general terms what would make their results more believable (increase in number of tests, increase in number of subjects, greater divergence from expected results, multiple groups getting the same answer). Complete this portion with a class discussion to go over answers. 11. Now ask that they answer the questions in the Experimental Conditions portion of the Student\_FoodScientistHershey. (This should take 10-15 minutes). Discuss answers with the class. 12. Ask students to now design an experiment, incorporating the answers of the different questions in the activity sheet (10-15 minutes). Start by asking to first ask if each group had an experiment that directly tests the hypothesis. I make one group come up and write their exp design on the board, then the other groups comment based upon deviation between their groups experimental design and the sample one on the board. Focus on simplicity and directness of testing hypothesis. 13. **Conduct Experiments.** Conduct experiment and record data; i.e. eat the candy time (10-15 minutes). I found that I needed to emphasize the need to collect and record data. 14. **Analysis of Results.** Discussion. Set up a simple table on the board, with group name, Percentage correctly identified, number of M&M tasted for each subject. Note that each line of the table=one experimental subject; so each group can have more than one entry. Fill in the table. (If using subunit II, then answers should be on excel. Instructions on Teachingunitinstructions within that subunit). 15. Analyze data. Ask if there is a difference. Which result do they believe? What is the outlier? What are the factors that will give them a greater ‘confidence’ that a particular result is ‘real’. (Number of repeats, number of experiments, deviation from the expected result). Please refer to Faculty\_FoodScientistHershey\_ANSWERKEY). 16. **Conclusions, and revising hypothesis.** Ask students what conclusion they can reach from these results. Discuss what follow-up experiments they would conduct in order to confirm their results; or based on the conclusions of these results (If using subunit III, point out how revision of hypothesis is an important part of The Scientific Method). 17. If you would like to use **subunit I:** **Experimental Design and Hypothesis testing in the Real World**, please begin here. If you are using **subunit III: Philosophy of Science. Objective vs. situated science,** discussion on Kuhn should begin here. If using both, I suggest completing subunit I, before discussing Kuhn in subunit III. |