# Lesson Plans

## Research Skills

## ENG Lesson 1: Office Etiquette & Professionalism

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to give examples of expectations of workplace etiquette and email etiquette that they will follow.
- LO2: Students will practice composing a professional email.
- LO3: Students will be able to identify do's and don'ts about the professional workplace habits.
- LO4: Students will clarify any questions or concerns they may have regarding expectations for professionalism and behavior during summer sessions.

**Materials & Supplies:**
- Laptop

- Projector
- Whiteboard/chalkboard
- Marker/chalk

**Introduction (10 minutes):**
As this is the first workshop of the ENG program, start with an icebreaker activity (e.g. two truths and a lie) that allows the students to get to know each other.

**Activity 1 (15 minutes):**
(5 min)
1. Ask students to write down the ten things they think are most important for office etiquette and professionalism. Examples might include: coming on time, not playing loud music, responding to emails in a timely manner, etc.
2. In pairs, students will share their top tens and decide on the ones they feel are the most important.

(5 min)
3. Class share-out: Ask students to share out their ideas on their top ten things they think are most important in office etiquette/professionalism.
4. Based on your experiences in work settings, show your top ten ranking.

**Activity 2 (15 minutes):**
(10 min)
5. Divide the class in half. Give the following two case studies. Ask half of the students to identify areas of improvement for example 1; the other half will identify areas of improvement for example 2.

*Example 1*

| |
|---|
| **(no subject)**<br><br>Hi can you please give me a discount |

*Example 2*

| |
|---|
| **Subject: hw**<br><br>Hi,<br><br>I need an extension on my hw.<br><br>-student |

6. Students share out their suggested improvements for the emails. Workshop the emails with them until the email is professional and adequate.

**Activity 3 (20 minutes)**
(10 min)
7. Case studies: divide students into 4-5 groups (around 4 per group), and assign a case study to each group. Please give a scenario from your own personal experiences (e.g. miscommunication between student and supervisor, conflict between students during

groupwork, disagreeing with the supervisor/teacher, etc.) to each group. Ask students to identify the issue, what is “tricky” about the problem, and what steps they would suggest (have these instructions/questions on the powerpoint slide).
(10min)
8. Share-out: students come up and present to class what their scenario was (make sure you have the scenario in your powerpoint slide), and how they addressed it.

Debrief (5 min)
Ask students to share 3 main takeaway points and give a chance for students to ask questions about situations they’ve encountered. Encourage the students to speak with program staff if they encounter issues during their program.

# ENG Lesson 2: What is Scientific Research?

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to give an example of how scientific research has evolved over time to produce what we know today.
- LO2: Students will be able to describe the difference between engineering and science.
- LO3: Students will be able to describe how scientific research is communicated and shared.

**Materials & Supplies:**
- Laptop
- Projector
- Whiteboard/chalkboard
- Marker/chalk

**Introduction (10 minutes):**
Think-pair-share: Give students two minutes to write down their thoughts on "What is Scientific Research?" Give 4 minutes for a pair discussion (2 minutes per person). Ask students to share what they discussed in their pairs voluntarily with the class (4 min).

**Activity 1 (15 minutes):**
(5 min)

6. Have all of the students write down on a sheet of paper five inventions that were made in the 21st century.
7. Ask each student to read out his/her answers. Write them up in the middle of the whiteboard. Answers are likely to be heavy on technology, so also include advances such as:
    - Refrigeration
    - Medical advances (x-rays, surgeries, sanitation)
    - Genomics
    - Travel (cars, planes, trains)
    - Telescopes
    - Radar

Example:

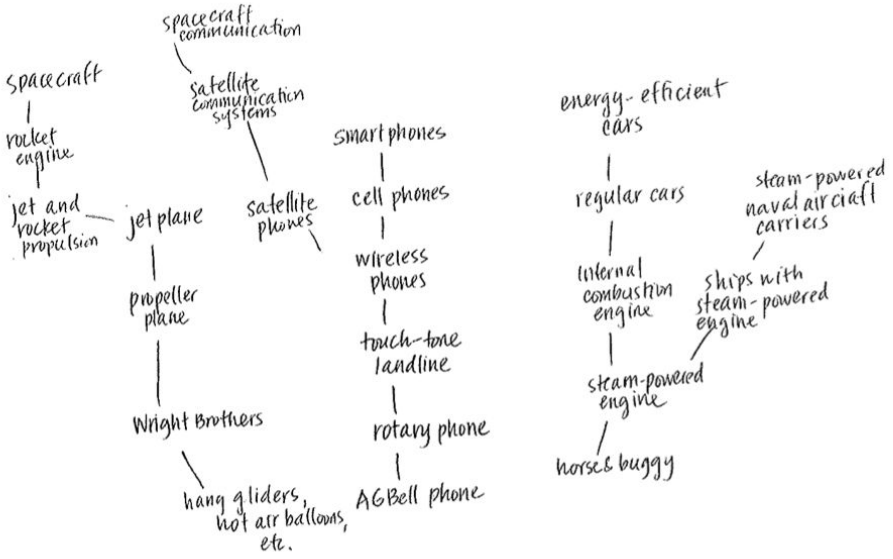

(10 min)

8. As a group, select one of the technological advances on the board and think about what its predecessor would be. E.g. the predecessor to the smartphone would be the cellphone,

followed by touch-tone landline phones, the rotary phones, and eventually the telephone designed by Alexander Graham Bell. Write each predecessor in order on the board and connect them with lines.Repeat this process with a few more of the items, and when possible, try to converge their histories (aka show how certain technological advances resulted in multiple technologies today, e.g. the Internet resulting in many current technologies).

9. You should get something that looks similar to a tree with multiple branches. Leave space at the top of the "branches." Emphasize that most of these inventions were not the result of one scientific discovery, but usually the result of many discoveries in different fields.

Example:




**Activity 2 (25 minutes):**

(5 min)

1. Begin the second activity by summarizing some of the important engineering and scientific discoveries from the previous activity. Then ask the students for an explanation on what they think is the difference between engineering and science.

(5 min)

2. Play the video https://www.youtube.com/watch?v=bipTWWHya8A and then ask students what they believe was the main takeaway from the video.

(4 min)

3. Go back to the whiteboard from the previous activity - there should still be space above the technological suggestions from the previous activity. Ask each student to come up with a new invention that addresses a problem that needs solving, or is an improvement upon one of the inventions listed on the board.

(6 min)

4. Then, have each student present his/her idea. Ask them what types of engineering might be involved in designing and producing their new inventions.

(5 min)

5. End the activity by mentioning that communicating your findings is just as important as doing the research. Ask students how they learn about new scientific discoveries. Common answers may include: news, internet, school textbooks, social media.
6. Explain that in the academic community, most new advances are communicated through publishing primary research articles in academic journals and making presentations at science conferences and conventions. Academic research tends to be at the leading edge of human thought and exploration, while research at government and company research labs tends to be focused on more near-term projects.

**Wrap-Up/Homework Assignment (10 minutes):**

Give a quick overview of the schedule of workshop topics and the expected attendance at workshops. Explain that attendance will be taken, and that someone from the ENG program office will be at each workshop and be available to talk about any issues that arise.

# ENG Lesson 3: Lab Culture & Keeping a Lab Notebook

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students should be able to identify the various positions and hierarchy in a laboratory setting, and understand that each lab is unique.
- LO2: Students will be able to delineate how and when to approach different members of the laboratory group.
- LO3: Students should be able to identify appropriate and inappropriate behavior inside the lab.
- LO4: Students will be able to list multiple reasons for documenting scientific processes, even those that are unsuccessful, and list at least three methods to document.

**Materials & Supplies:**
- Laptop
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Paper (enough for each student)

**Introduction (10 minutes):**
Start this workshop with a rose, bud, and thorn activity. Have the students go around the room and share their rose (something good that happened this past week), a bud (something they are looking forward to in the program), and a thorn (something they are worried or concerned about). Ask them to say it in the order of thorn-rose-bud.

**Activity 1 (20 minutes):**
For most students, this will be their first time in the lab setting. As it is week two, some if not all students should already be familiar with the people in their lab.

(4 min)
1. Ask the students to list the types of people they have met so far in their research lab. Students should also know the various roles in the lab, such as:
    - Principal Investigator: usually a professor who has received funding from a grant application to conduct research on a specific topic
    - Postdoctoral Researcher: Someone who has already earned their PhD in a field and is conducting research
    - Graduate Students: Students who have already gained a bachelor's degree and are in pursuit of a Masters of PhD. Graduate students are usually working on a research project towards a thesis or dissertation.
    - Undergraduate Students: Students who hope to gain lab experience. Experienced undergraduate students may begin working on their own experiment for their senior honors thesis.
    - (Maybe also add in lab technicians)

(4 min)

2. Ask the students to create a list of as many questions as possible that they might have in their lab.

(5 min)

3. Ask the students to share their questions with the class, and ask the class who they think would be the appropriate person in the lab to ask. In many cases, multiple answers may be correct, but there may be some confusion about when to talk to a graduate student vs. a faculty member.
4. Mention that students should understand that each lab is unique, and that many labs are more casual than the classroom environment. That does not mean that students should not act professionally or safely, but it does mean they should build relationships and learn from their coworkers.

(2 min)

5. Also remind students that, while the primary purpose of ENG is to expose students to academic research, they should also take advantage of being at a university. There are numerous summer programs and seminars that they are welcome to attend (listed on the ENG calendar), and there may be additional events specific to their lab that their graduate student mentors may invite them to attend. They should take advantage of these as well, and ask their graduate students about these opportunities if they have not already mentioned them.

(5 min)

6. Share your own experience working in various research settings, e.g. as a postdoc and in earlier positions.

**Activity 2 (15 minutes):**

This activity is focused on appropriate behaviors and how to set a good impression in the lab.

(3 min)

1. Give each student a piece of paper and a pencil and ask them to follow your instructions. Students are not allowed to ask any questions about the instructions:
    - Draw three squares, each one a different size
    - Shade in half of the smallest square
    - Draw a triangle outside the middle square
    - Draw an X inside the largest square
    - Below the smallest square, draw another square of the same size
    - Shade in half of the new square
    - Shade in the top part of the triangle
    - Below the square, draw a smaller triangle
2. In the end, students should all have different images after finishing these instructions. The trick is that there is a correct image: show it to them, and see whether anyone's drawing was close (although it does not matter).

(5 min)

3. Show these instructions on a PowerPoint slide, and then ask the students to rewrite these instructions in a way where there is no ambiguity and will always produce the same image. You may split the class into pairs and assign a few instructions to each pair to re-write.

(2 min)
4. Go around the class and have each pair read off their instructions.

(5 min)
5. Ask the students how this activity relates to scientific research. Answers should include that detailed instructions are important, and that instructions should allow anyone to repeat their research/experiment.
6. Make sure it is noted that sometimes we do not always know what the final image is supposed to look like. Emphasize that it is equally important to document past failures in your notes so that people when reviewing your notes will be able to avoid your mistakes and waste less time and resources testing hypotheses that have already been tested.

**Short lecture – Best Practices & Adequate Behavior (10 minutes):**

1. Best practices for interacting with lab members
    a. Colleagues you are working with
        i. PI: You will not see this individual often.
        ii. Postdoc: You will not likely interact with a postdoc either. Typically postdocs oversee graduate students.
        iii. Graduate Students: Your mentor/direct contact in the lab will likely be a graduate student who is leading the project with which you are working.
        iv. Undergraduate Students: In similar shoes as you.
    b. Respect others' time
        i. Schedule meetings in advance.
        ii. Have discussion points ready for meetings.
        iii. Take detailed notes when trained in lab (good enough notes so that you could do it on your own without any help).
        iv. If someone looks rushed/busy/stressed, ask if there would be a better time to meet with them.
    c. Ask questions often
2. Adequate behavior
    a. Arrive on time and stay until grad student or postdoc says you are finished for the day.
    b. Wear adequate PPE → Ask your mentor if they don't advise you on this.
    c. Respect the project. This is what the graduate student or postdoc is working diligently on for many, many, many years.

**Wrap-Up/Summary (5 min):**

Remind students to ask the questions that they wrote down previously in their research labs, and tell them to get to know the people in their lab. See if anyone has any questions.

# ENG Lesson 4: The Scientific Method

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students should be able to identify the various steps in the scientific method and the order in which they operate.
- LO2: Students will be able to explain the difference between observation and inference.
- LO3: Students will be able to give examples factors that may affect human observation and ways in which we can control for human error.

**Materials & Supplies:**
- Laptop
- Projector
- Whiteboard/chalkboard
- Marker/chalk

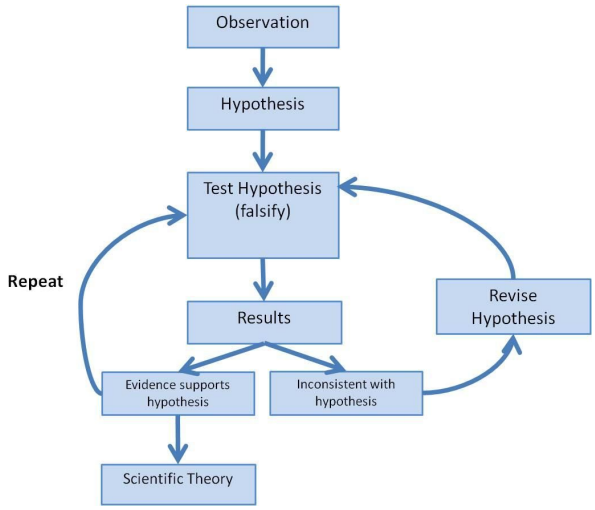
**Introduction (10 minutes):**
1. Follow up with the students and ask them whether they were able to ask their questions about the lab culture. Answer any additional questions they have.
2. Ask one of the students to provide a brief review of what was discussed in the previous workshop.

**Activity 1 (20 minutes):**
Explain that today and tomorrow's workshops will focus on the scientific method and experimental design. Most students, if not all, will have some experience with these topics, but a quick review will be helpful.

(3 min)
1. Split the class into groups of 3, and ask them to draw the scientific method with arrows pointing to each step.

(4 min)
2. Then, ask each group to present their drawings.

(2 min)
3. Once each group has presented, compare it to the image below and note any important differences. The most likely difference will be that they forgot about iteration and repetition, so be sure to stress that this is an important part of the scientific method.




*http://elearning.la.psu.edu/anth/021/lesson-2/images/StepsoftheScientificMethod_blue.jpg*

(3 min)

4. Now show the students this video: http://www.pbslearningmedia.org/resource/hs11.global.ancient.earl.monkeysee/the-human-spark-monkey-see-monkey-take/

(5 min)

5. Ask them to identify (in the same groups) the various parts of the scientific method in this video: What was the observation? The hypothesis? How did they test this? How did they collect data? What changes should be made to their experiment?

(3 min)

6. Review answers together as a class.

**Activity 2 (15 minutes):**

(3 min)

1. Explain that you will be looking more closely at the first step of the scientific method: observation. Observation may appear to be an obvious term, but observation can often be confused with inference, and several things can skew our senses when making observations.

(7 min)

2. Show the students a PowerPoint of optical illusions (http://www.cslab.ece.ntua.gr/~jdros/humor/OpticalIllusions.ppt) and ask everyone to share what they see. Go through as many as you feel appropriate or what time will allow.
3. When you are done, ask the students why they might have seen these same objects differently. Common answers should include: many things can change the way in which we observe things, people see things differently, what is obvious is not always obvious, etc. Some images required special instructions for the illusions to work. It is important to be as objective as possible when making observations, as some things that may appear certain to one person are not so certain to another.

(5 min)

4. Now connect this to the lab setting. Ask the students to brainstorm a list of things that may affect our ability to observe scientific phenomena. Write these on the board.
5. Ask the students how we can control experiments to account for these effects. For instance, humans may see the same color light differently, so instead of recording a color, we can measure the wavelength of the light produced.

**Activity 3 (10 minutes):**

1. To further demonstrate the difference between observation and inference, show the students the following image: https://middleschoolscienceblog.files.wordpress.com/2015/06/goat_boy_water_observations.png?w=1164&h=874
2. Ask the students what they see in this image. Some may give general descriptions of the image, e.g. there is a goat, a boy is in the water, etc. Others may make suggestions as to what happened, e.g. the goat pushed the boy in the water, the boy went to grab the boat, etc. Write all of these on the whiteboard. Try to get 10 statements on the board.
3. Now explain to the students that you only want observations on the board, not inferences about what happened. Go through each statement on the board and determine whether it is an inference or an observation. Together, label each statement “inference” or “observation.”

**Wrap-Up/Homework Assignment (5 minutes):**

Ask the students to each share an insight that they had from today’s workshop. Allow time for any additional questions, and then tell students that they will focus on experimental design in the next workshop.

# ENG Lesson 5A: Experimental Design 1

**Date:**
**Facilitator:**
**Duration:** 45 minutes

**Learning Objectives:**
- LO1: Students will be able to point out tenets of sound experimental design and basic concepts of variables.
- LO2: Students will practice using the scientific method to create/plan an experiment.

**Materials & Supplies:**
- Laptop
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Copies of primary research article (also add to ppt slides)

**Introduction (15 minutes):**
1. Matching activity: Have students match the research questions with the investigation steps (jumble them on the powerpoint), based on the following question: fdsafdsafdsa

**Activity 1 (25 minutes):**
(10 min)
1. Split the class into two groups and ask the students to think of an observation (e.g. something that doesn't work as well as it should, or a scientific phenomenon).
2. Once each group has come to a consensus on one observation they want to discuss, ask them to develop a hypothesis about their observation (e.g. a way in which a process could be improved, or a possible explanation for a phenomena).
3. Once they have developed a testable hypothesis, have them create an experimental design that will allow them to test their hypothesis. They can assume that they have unlimited resources for this part, as the purpose is simply to have them understand the experimental design process.

(8 min)
4. Show the scientific method diagram again. After each group has completed their experimental design, ask one person from each group to explain how it fits into each of the steps in the diagram, i.e. their observation, the hypothesis they developed, and the experimental design they created to test their hypothesis (ask them to state the independent and dependent variables, constants, and the control group). Students should ask questions of the presenting group to determine if the experimental design is sound.

(7 min)
5. Take a moment to discuss how scientists can account/control for variables that are out of their control, such as doing an experiment that involves humans. For instance - in the medical setting, you may want to test how a particular treatment will work on individuals with a certain disease. Ask the students to quickly design an experiment that would test this.

6. Next ask them how they should control for certain variables: how will you control for age, sex, height, weight, etc.? Students may create a large list of controls, which is ok. Mention that many researchers cannot always control for these factors and often using so many controls limits the applicability of research findings. In its place, researchers often use large sample sizes and randomization to take into account variables they cannot control or are not even aware of.

**Activity 2** (30 minutes): Students design an experiment

1. Giving each student a slip of paper from this website page: https://www.biologycorner.com/worksheets/sci_method_scenarios.html. Ask the students work in pairs to design an experiment that will test the question that they were given (15 minutes)
2. Then, ask each student to quickly present their experiment to the class, explaining their hypothesis, controls, independent and dependent variables (15 minutes).

**Wrap-Up/Homework Assignment (5 minutes):**

Ask the students for one insight that they gained from this workshop. Then, ask them how they believe they can use what they learned this week in their research this summer. Allow time for any questions at the end.

# ENG Lesson 5B: Experimental Design 2

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will practice using the scientific method to create/plan an experiment, and will present their experimental designs to the class.
- LO2: Students will be able to outline and practice methods of navigating and learning difficult jargon found in primary research articles and identifying main concepts/points being made.

**Materials & Supplies:**
- Laptop
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Copies of primary research article (also add to ppt slides)

**Activity 1 (20 minutes):**
(5 min)
1. The purpose of this activity is to connect the basic idea of the scientific method to advanced research occurring in academic settings. Hand out copies of a primary research article and ask the students to read the abstract and methods section and find the independent and dependent variables.

(5-10 min)
2. Next, ask them if they can find what the control group was and how they controlled variables that were not being tested in this experiment. This may be difficult for the students depending on their previous exposure to primary research, so encourage students to read carefully but not be paused by difficult jargon. Then, as a group, ask the students to summarize the experimental design of this experiment.

(10 min)
3. Conclude by asking students to draw similarities between the simple experimental design/scientific method diagram to the contemporary research article.

**Activity 2** (25 minutes): Students design an experiment
3. Giving each student a slip of paper from this website page: https://www.biologycorner.com/worksheets/sci_method_scenarios.html. Ask the students work in pairs or small groups to design an experiment that will test the question that they were given (15 minutes)
4. Then, ask each student to quickly present their experiment to the class, explaining their hypothesis, controls, independent and dependent variables (10 minutes).

**Wrap-Up (5 minutes) – if time allows:**
Ask the students for one insight that they gained from this workshop. Then, ask them how they believe they can use what they learned this week in their research this summer. Allow time for any questions at the end.

# ENG Lesson 6A: Using Excel 1

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students should identify and recognize the basic elements of Excel, e.g. cell, formula, functions, etc.
- LO2: Students should be able to manage a database in Excel i.e. create tables, format, use filters, sort, etc.
- LO3: Students should learn some time-saving techniques that will allow them to get their work done faster with Excel

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Ruler
- Computer lab (book in advance)

**Introduction (10 minutes):**
1. The introduction for this activity will be collecting the data that will be used in this Excel exercise. Our data will be reaction times for catching a falling ruler. Students should work in pairs (possibly with one group of 3).
2. One student will drop a ruler directly above as such (https://cdn-assets.answersingenesis.org/img/articles/am/v8/n3/ruler-experiment.jpg). This should be done twenty times, and the reaction "time" will be the distance on the ruler from the bottom to the thumb of the catcher.
3. Switch roles and repeat another twenty times. Data should be organized into three columns: Trial # (1-20 twice), Ruler Distance, and name of the catcher.

**Activity 1 (40 minutes):**
(10 min)
1. First, get everyone's data looking nice and uniform. Instruct students to highlight the column with the distance values (this can be done by simply clicking or double clicking the column header). Then, right click and select "Format Cells." Click "Number" and set the number of digits after the decimal ("Decimal places") to 1. This allows everyone to use significant figures in excel documents (which will be covered in the statistics class).
2. Now, if students took turns catching, try to sort the data to make sure it is clumped as trial 1-20, catcher A and trial 1-20, catcher B. Instruct the students to have headers on their table if they do not have them already; Excel will automatically detect if there are already headers on the first row for the column and will ignore these cells when sorting. Select the "Catcher" column. On the top toolbar, there should be a funnel icon — this is the sort button. We want to see the results of each catcher clumped together, so click on the funnel, then click "Sort A to Z," then click "expand selection." The results should appear as trial 1-20 catcher A then 1-20 catcher B. This is important for using functions, which require specific cells to be used.

3. Now that they have seen the sort function in action, students will calculate each participant's average distance. Ask the class whether they already know the function in excel to do this (it is =AVERAGE(range)). Ask them to select the range and write it as firstcell:lastcell. Calculate the average for both participants.

(15 min)

4. To show an example of some other functions, have students test whether or not a certain value was an outlier by creating a 95% confidence interval. Ask the students to calculate the standard deviation for their data (using =STDEV(range)). Then, ask them to think of an equation in excel that will allow them to calculate the upper value of the confidence interval (the answer is =(average)+2*(stdev)) and the lower value (-2*(stdev)).
5. Now we want to go through each data value and make sure that it is in our 95% confidence interval. Create a new column titled "Outlier" We want this column to have either yes or no values. Introduce the "If" function. The "If" function requires three clauses - the first is the condition you are testing, the second is the output if the condition is met, and the third is the output if the condition is not met. Ask the students to try to figure out the correct equation that will determine if the data point is an outlier or not (the answer is IF(AND(B3<E$9,B3>E$10),"yes","no") (numbers/cells will vary). Let the students try a few times, then introduce the AND function, and also mention that if you want Excel to print words in a cell, the words need to be in quotations.
6. Instead of yes and no, we want the system to either output the number if the value is not an outlier, or an empty cell if the value is an outlier. Students should simply take the function they created earlier and change the two outputs to =IF(AND(B3<E$9,B3>E$10),B3,"").
7. Mention that there are many more functions that Excel can use, and encourage students to look up excel functions on their own time.

# ENG Lesson 6B: Using Excel 2

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will practice managing a data set in Excel, i.e. set up a workbook, input data, input formulas, produce answers.
- LO2: Students should apply time-saving techniques that will optimize their efficiency and effectiveness with Excel.
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**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Ruler
- Computer lab (book in advance)

**Introduction (5 min):**
(5 min)
1. Ask students to recap what they learned yesterday – what was the experiment, how did they input the data, how did they arrange the data, what functions were used, etc.

**Activity 1 (40 minutes):**
(5 min)
2. Now that functions have been covered, students should learn the basics of creating graphs in excel.
3. Have the students highlight the first three columns of their table, and click on a scatterplot graph (insert>charts>scatter). The result will almost surely not be what you want. Explain that, in order to graph things correctly in Excel, tables need to be organized in a specific manner depending on the type of graph you are creating.

(10 min)
4. To the side, ask the students to create a table where the first column is still 1-20 trials, the second column is one student's distances, and the third column is another student's distances.
5. Now re-highlight the columns and see what graph is produced. It should look much cleaner and close to what you want.

(10-15 min)
6. One thing we want to examine is whether or not there was any improvement in distance over time. Graphs allow us to make a visualization of this (ask students how), but we want to know specifically if is a trend. Click on the graph and go to the "Chart Layout" tab. There, you should be able to create a trend line. Add a linear trend line for both participants.

7. A trendline is nice, but it's not that useful if we do not know the equation for the line. Luckily, Excel has already calculated this. Instruct the students to right click on the line in the graph and choose "Format Trendline". In the options, there should be an unchecked box that says "display equation on chart" and "display R-squared value on chart". Click both of those boxes, and the equation and R2 value should appear.
8. Ask the students to explain what the trendline equation means for their experiment (Answer: The reaction time/distance on the ruler decreases as more trials are done by x coefficient). Some students may be aware of what the R squared value is, so ask the class to see if anyone knows. If not, simply explain that it is a measure of correlation in the data. An R-squared value of 1 would show the data points in a straight line along the trendline, while an R squared value of 0 would show purely random points. Ask the students what they received as R-squared values and see which one has the highest.
9. The trendline that was created was a linear trendline, but would an exponential trendline work better? Let the students test this by asking them to repeat the steps in the previous paragraph, but for the exponential trendline. How should the students compare which trendline is a better representation? (Answer: the R squared values should be higher for the trendline that predicts a better trend).

**If time allows:**

Give students another data set and ask them to find the average, mean, standard deviation, trendline, etc.Ask – what are some applications of excel? Where do you think the program might come in handy? What are some things that you would like to try in excel? Etc.

# ENG Lesson 7A: Statistics Part 1

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to explain why statistics are necessary in scientific research and in reporting findings.
- LO2: Students will practice calculating a p-value and will be able to describe how sample size affects statistical findings.
- LO3: Students will be able to identify conditional probabilities and other situations where simple probabilities cannot be calculated.

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk

**Introduction (5 minutes):**
Ask students to work in pairs to come up with their own definition of what Statistics is. Share the official definitions from the Merriam-Webster and Oxford dictionaries. Ask volunteers to read the definitions aloud. Mention that the data collection and analysis that they did in their last lesson is a good example of what statistics involves. Show other examples of statistics (Pokémon Go and Poll Average graph).

**Short interactive lecture (10 minutes):**
(5 min)
1. Explain what P is (probability of something happening). Explain what Q is (probably of something not happening).
2. Give examples, e.g. probability of rolling a die and getting a 4:
   P = probability of getting 4 = 1/6;
   Q = probability of not getting 4 = 1-P = 1-1/6 = 5/6

(5 min)
3. Ask students for various P and Q numbers from different scenarios, e.g. dice, deck of cards, red-green-yellow-blue spinner, etc.

**Activity 1 (10 minutes):**
1. Seems simple enough. Next, open up this link (http://www.columbia.edu/~ad3217/theme_park/startgame.html) and go through as many as you feel are appropriate. Students will realize that statistics is about more than just probability.

**Short interactive lecture (10-20 minutes):**
(5-10 min)

1. Note: Remember that this might be the first time learning about stats for some of the students, so try to use analogies, examples, and clear explanations free of jargon.
2. Testing hypotheses involves constructing two statements: the null hypothesis and the alternative hypothesis. Mention that they might look similar when written but are not.
3. Without using too much jargon, describe the null hypothesis — $H_0$ reflects that there will be no observed effect for the experiment. It is the evidence we attempt to find that works against our hypothesis. Researchers are usually trying to prove the null hypothesis wrong.
4. Mention that even if a null hypothesis is not rejected, students must be careful when describing what that means. Give the analogy of a legal verdict: just because a person has been deemed "not guilty" does not mean that s/he is innocent. Similarly, even if the null hypothesis is not rejected does not mean that the statement is true.
5. The alternative or experimental hypothesis, $H_A$ reflects that there will be an observed effect for the experiment. If the null hypothesis is disproved, then the alternative hypothesis is accepted. If the null hypothesis is not rejected, then the alternative hypothesis is not accepted. In other words, "innocent until proven guilty" — $H_0$ until proven $H_A$.

(5-10 min)

6. Ask for ideas on how to prove $H_A$. Give examples of correct answers.
7. Give an example of an experiment and prompt students to create a null and alternative hypothesis. Provide guidance until they are able to create these hypotheses as a class. Alternatively, provide sets of hypotheses (similar to multiple choice) and have them select the best null/alternative hypothesis.

**Activity 2 (10 minutes):**

1. On your PowerPoint, show the statement "Correlation does not imply causation."
2. Ask the students what they think this means. Look for answers stating that correlation shows a relationship between two things, causation shows something causes another thing, correlation between two variables does not imply that one variable causes the other, etc.
3. Emphasize the difference between correlation vs causation.
4. Show the page: http://graphics.wsj.com/elections/2016/facebook-likes/?mod=e2tw. Ask students to give examples of correlations shared by the article. Emphasize that these are *correlations*, not causations. I.e. Clinton likers happen to generally have a preference for pop music over country music while Trump likers tend to prefer country. People do not like Clinton *because* they like pop music or vice versa.
5. Consider using some examples from here: http://www.fastcodesign.com/3030529/infographic-of-the-day/hilarious-graphs-prove-that-correlation-isnt-causation and http://www.tylervigen.com/spurious-correlations

**Wrap-Up/Homework Assignment (5 minutes):**

Allow room for questions. Mention that tomorrow they will have a second lesson on statistics. Encourage them to reach out to each other if they think of additional questions later. Take any last questions.

# ENG Lesson 7B: Statistics Part 2

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to use normal distributions to identify means and standard deviations.
- LO2: Students will be able to describe how different types of distributions will affect standard deviation or mean values.
- LO3: Students will be able define what confidence intervals are and describe how CIs are related to distribution plots.

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk

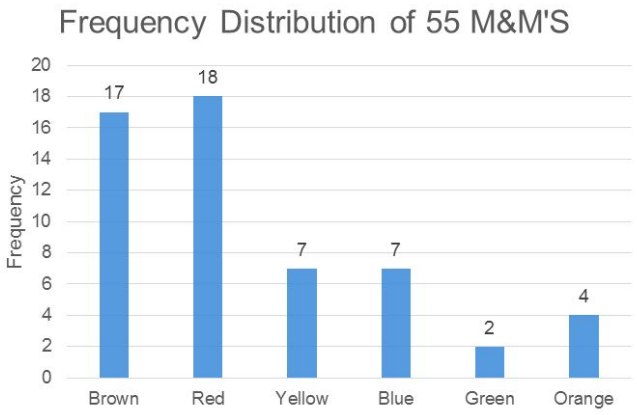
**Introduction (5 minutes):**
1. Ask students what they think “distribution” means when it comes to statistics. If they do not know, prompt them until they figure it out. Once they know what a distribution is, give them the definition of a distribution.
2. Next, ask them to list/give examples of the distributions that they know. Some possible answers: bell curve (normal distribution), uniform distribution, frequency distribution, probability distribution, etc. Have examples of these ready to show them in the PowerPoint.

**Activity 1 (20 minutes):**
(5min)
1. Activity 1 will introduce frequency and probability distribution using an M&Ms example. Tell students that in this experiment, 55 M&Ms were counted: 17 brown, 18 red, 7 yellow, 7 green, 2 blue, and 4 orange. Show these counts in a table like the one below.

| Color | Frequency |
|---|---|
| Brown | 17 |
| Red | 18 |
| Yellow | 7 |
| Blue | 7 |
| Green | 2 |
| Orange | 4 |

2. Note that “frequency” in this case is how often each color was found.
3. On the board, draw/set up a graph with the title, “Frequency Distribution of 55 M&Ms.” The y-axis should be Frequency, 0-20 in intervals of 2, and the x-axis should be Colors (brown, red, yellow, blue, green, orange).

4. Ask volunteers to graph the frequency distribution of M&Ms for each color. I.e. one person will come to the board and graph each color. When they are finished, it should look like this:

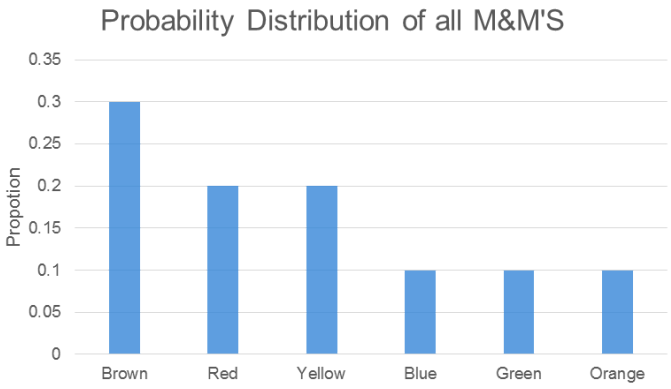



(5 min)

5. Give the students another Frequency table with different frequencies of M&Ms (just make up your own data). Ask students to draw their own distribution for the table. Go around the room as they work to check their work. Go over the answer as a class.

(10 min)

6. Next, ask students to calculate the probability of each color. Review the answers as a class.
7. Ask a volunteer to set up the axes for a probability distribution on the board. Ask volunteers to each graph the probability of one color. The numbers will be different, but the probability distribution should look something like this:




**Activity 2 (15 minutes):**

1. Activity 2 will introduce the concept of bias, how data is distributed differently, and how it relates to mean/median/mode. First, tell students that data can be distributed differently. For example, it can be "biased" toward the right or left. Use this page for reference, if necessary https://www.mathsisfun.com/data/standard-normal-distribution.html. Try to provide visuals and examples for everything.
2. Introduce the concept of a "normal distribution" which is shaped like a bell curve and shows data around a central value with no bias left or right.

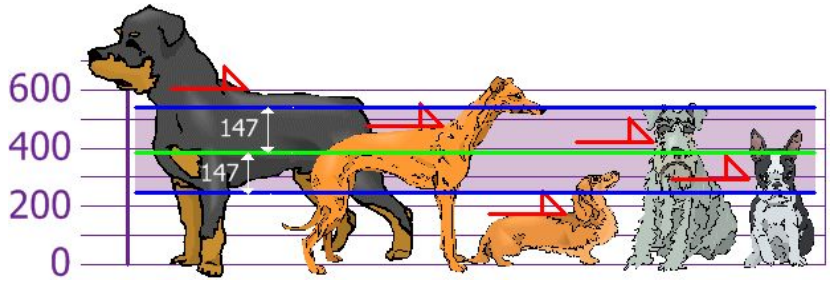
3. Ask students to give examples of things that they think might follow a normal distribution. Then give examples: height of people, size of things produced by machines, errors in measurements, blood pressure, marks on a test, etc.
4. Describe how this normal distribution relates to mean, median, and mode — with a normal distribution, there is a symmetry in the graph and the central value usually demonstrates a similarity where mean=median=mode (or they are close).
5. Refresh students on how to calculate the mean, median, and mode of the set of values. Give them the numbers 7, 8, 5, 10, 10. Mean: add up all the values then divide by how many values there are. Median: put the numbers in order from smallest to biggest. The median is the middle number in the sorted list. Mode: put the numbers in order, then count how many of each number. The number that appears most often is the mode.
6. Have them calculate the mean, median, and mode for this set. Mean = 8, median = 8, mode = 10.

**Activity 3 (20 minutes)**

1. Activity 3 will focus on introducing and reinforcing standard deviation. Start by explain what standard deviation is (measure of how spread out data is). Under "Additional Resources" you will find links for different ways to clarify the purpose and definition of standard deviation.
2. Tell students standard deviation is denoted by the symbol $\sigma$ (the greek letter sigma). Give the formula for calculating the standard deviation: the square root of the variance. The formula for variance is the average of the squared differences from the mean.
3. Together as a class, use this to calculate the standard deviation of the same set of numbers, 7, 8, 5, 10, 10.

    Example: 7, 8, 5, 10, 10
    Mean = 8
    Variance = $( 7 - 8 )^2 + ( 8 - 8 )^2 + ( 5 - 8 )^2 + ( 10 - 8 )^2 + ( 10 - 8 )^2$
    $= 1 + 0 + 9 + 4 + 4$
    $= 18$
    Standard Deviation $\sigma = \sqrt{18} = 4.2$

4. Remind students that standard deviation is a measure of how spread out data is. Ask students for examples of when we use standard deviation.
5. Give the students a last example — this time they will calculate everything individually. Use the example with the dog heights from this link: http://www.mathsisfun.com/data/standard-deviation.html. Ask the students to calculate the standard deviation. Break the process into steps, just like the website shows.
6. Have students share their answers. Then show the graph with the standard deviation with dog heights.




7. Ask them what this picture demonstrates. They should say that the Rottweiler is particularly tall and the Dachshund is particularly short.
8. Note that when statisticians are calculating standard deviations, the formula changes depending on whether it is a population (small data set) or a sample (large data set). State this merely as a side note — make sure it does not confuse the students.

Wrap-Up/Homework (5 minutes)
Ask students if they have any questions and allow time for answering them.
Additional Resources:
http://www.businessinsider.com/standard-deviation-2014-12
http://onlinestatbook.com/2/introduction/distributions.html
http://apstatsmonkey.com/StatsMonkey/m&m_Activities_files/Statmnms.pdf.

# ENG Lesson 8: Ethics in Research

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students should understand that science research can have effects on non-science fields, such as the economy or politics
- LO2: Students should understand that ethics in research are not always simple but instead are often complex.
- LO3: Students should be able to think critically about what it means to be an ethical researcher

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Copies of NY Times article
- Copies of primary research article for students

**Introduction (10 minutes):**
1. Pass out copies of the article http://www.nytimes.com/2010/08/21/education/21harvard.html and ask the students to read it.
2. Ask a student to provide a brief summary. Begin a discussion with the class on major takeaways.
3. End by mentioning that, shortly after this article was published, the professor in question resigned from Harvard University, so ethics in research is incredibly important. Transition to today's topic on ethics in research, both how to be ethical in the lab and current scientific debates.

**Activity 1 (30 minutes):**
(5 min)
1. The majority of this workshop will be spent in a debate format. Split the class into two equal groups. One side of the room will be tasked to defend one side of an argument, and the other team will be arguing against them. The topic: Genetically Modified Organisms
2. Ask anyone if they have heard of GMOs before. If so, ask them if they can give a quick definition of what a GMO is. Then, play the following video: https://www.youtube.com/watch?v=aCWH7PlBKBw (5 minutes)

(10 min)
3. Tell the students that one side is going to defend the use of GMOs in agriculture, while the other side will argue that GMOs should not be used in agriculture. Then give each team 10 minutes to discuss. While they are discussing, check in with each group to hear how they are going and provide suggestions if they appear stuck.

(5 min)

4. The structure of the debate can go as follows:
   Opening statements (1 minute each)
   Rebuttals (3 exchanges, 30 seconds each)
   Final statements (1 minute each)

(10 min)

5. Afterwards, congratulate both sides for defending their stance on this issue. Ask students to summarize some of the important takeaways from the debate. Hopefully students mentioned not only scientific reasons, but also economic, health, or environmental reasons but if not, bring these up and ask them what they think are the economic, health, and environmental impacts of GMOs.
6. Briefly review the main points of the session. Emphasize that scientific research can have an impact on many other aspects of our world, and scientific research is not done in isolation. Science can have significant implications, both good and bad, for the environment, health, the economy, politics, etc.

**Activity 2 (10 minutes):**

Ethics in research does not just apply to controversial topics. Any form of research should be handled ethically.

1. Ask the students why it is important to behave ethically when conducting research. Common answers may include: promote the aims of research, promote collaboration, researchers have to be held accountable/build trust. Ask the students to brainstorm a list of ways in which they can be ethical in the lab.
2. List the following guidelines (with descriptions at the end of this worksheet): Honesty, Objectivity, Integrity, Carefulness, Openness, Respect for Intellectual Property, Confidentiality, Responsible Publication, Responsible Mentoring, Respect for colleagues, social responsibility, non-discrimination, competence, legality, animal care, human subject protection. Ask students to take turns reading aloud each.
3. Mention that students may be tempted to make small adjustments to their data in order to prove that there was a significant difference in their data. Be sure to stress that this is not ethical behavior, and that many scientists in the past have been shunned by the scientific community for doing such things. Although it may not be as attractive as finding significant differences, research that shows no differences is just as important to the scientific method and the science community.

**Wrap-Up/Homework Assignment (5 minutes):**

Pass out a copy of a primary research article to each student and ask the students to read it thoroughly and bring it to the next session. Students should be prepared to give a brief summary of the paper's key points by the next class and understand the key words and concepts. Students should also make a list of words that they do not understand as they are reading and bring that list to class.

**Ethics Guidelines**

Honesty: Strive for honesty in all scientific communications. Honestly report data, results, methods and procedures, and publication status. Do not fabricate, falsify, or misrepresent data. Do not deceive colleagues, research sponsors, or the public.

Objectivity: Strive to avoid bias in experimental design, data analysis, data interpretation, peer review, personnel decisions, grant writing, expert testimony, and other aspects of research where objectivity is expected or required. Avoid or minimize bias or self-deception. Disclose personal or financial interests that may affect research.

Integrity: Keep your promises and agreements; act with sincerity; strive for consistency of thought and action.

Carefulness: Avoid careless errors and negligence; carefully and critically examine your own work and the work of your peers. Keep good records of research activities, such as data collection, research design, and correspondence with agencies or journals.

Openness: Share data, results, ideas, tools, resources. Be open to criticism and new ideas.

Respect for Intellectual Property: Honor patents, copyrights, and other forms of intellectual property. Do not use unpublished data, methods, or results without permission. Give proper acknowledgement or credit for all contributions to research. Never plagiarize.

Confidentiality: Protect confidential communications, such as papers or grants submitted for publication, personnel records, trade or military secrets, and patient records.

Responsible Publication: Publish in order to advance research and scholarship, not to advance just your own career. Avoid wasteful and duplicative publication.

Responsible Mentoring: Help to educate, mentor, and advise students. Promote their welfare and allow them to make their own decisions.

Respect for colleagues: Respect your colleagues and treat them fairly.

Social Responsibility: Strive to promote social good and prevent or mitigate social harms through research, public education, and advocacy.

Non-Discrimination: Avoid discrimination against colleagues or students on the basis of sex, race, ethnicity, or other factors not related to scientific competence and integrity.

Competence: Maintain and improve your own professional competence and expertise through lifelong education and learning; take steps to promote competence in science as a whole.

Legality: Know and obey relevant laws and institutional and governmental policies.

Animal Care: Show proper respect and care for animals when using them in research. Do not conduct unnecessary or poorly designed animal experiments.

Human Subjects Protection: When conducting research on human subjects, minimize harms and risks and maximize benefits; respect human dignity, privacy, and autonomy; take special precautions with vulnerable populations; and strive to distribute the benefits and burdens of research fairly.

# ENG Lesson 9: Primary Research

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students should know what a primary research article is and be able to distinguish primary research from other publications
- LO2: Students should be able to identify the important sections of an article and know what information is included in each section
- LO3: Students should begin to develop strategies for and habits of navigating and learning difficult jargon found in primary research articles

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Computer lab (book in advance)
- Access to CU Library Network
- Primary research articles (students bring these)
- Sentence paper strips from research article
- Tape
- Web of Science access

**Activity 1 (15 minutes):**
(10 min)
1. Preparation: For this activity, you will need to prepare some materials beforehand. Take a research article that the students read for the assignment (they will have been asked to read this article as a homework assignment from the previous workshop), and select 20-30 sentences from all sections of the paper. Print them out and cut them so that each sentence is on its own slip of paper.
2. Using the paper that was assigned to the students, ask them to identify the main sections of the paper (Abstract, Introduction, Methods, Results, Conclusion, etc.). Write these on the whiteboard.
3. Then, pass out the slips of paper and ask the students to put these sentences in the proper category by taping the strips on the board. Go over these together as a class, pinpointing where exactly in the paper that sentence was found, and correct any mistakes.

(5 min)
4. Once this is complete, summarize your findings. What information did you find in the introduction, and how was it different from the conclusion? How were the results and the conclusion different? Which sections had the most citations?

**Activity 2 (15 minutes):**

1. Using a computer connected to the projector, log onto the CU Library database or go to google scholar.
2. Tell the students to imagine that they are the ones writing the research paper that they read for the previous class. They need to find research for their project, but they don't know what to search for. Ask the group for suggestions for keywords to search, and input the keywords on the connected computer using either google scholar or the CU Library database.
3. Search first for general terms that will produce a lot of results, most of which will not actually relate to the topic at hand. Then ask the students to brainstorm more specific words, and show how you can find more relevant research by producing longer, more complex/specific keywords.
4. The next step is to determine whether or not this research is relevant *and* quality research. Without reading any of the articles, ask the students to think of other qualities that you can use to filter your results. Likely answers may be: seeing how many times the keywords come up in the abstract, the number of times the article was cited, etc. Make sure to point out the name of the journal and the year of the publication. For certain fields, you may only want research in the past year or two, while in other fields, anything within the past 10-15 years would be considered recent.
5. Using these identifiers, choose an article from the results that is relevant and shows good quality research.
6. Review the process of putting in key words, specific terms, and checking the relevance and validity of the article.

**Wrap-Up/Homework Assignment (35 minutes):**

(30 min)

1. Tell students that during the final two weeks, they will be analyzing a primary research article in depth for multiple workshops. Now that you have gone through the process of searching for a research article, give the students a homework assignment to complete:
    - Find a primary research article published in the past 3 years on an engineering topic that interests them.
    - The paper should be at least 4 pages and preferably no more than 12 pages unless the student is ambitious.
    - Ask students to print a copy of this paper for tomorrow's workshop, where someone from the ENG program office will check to make sure it is good for the following workshops.
2. Students are to use the remaining 30 minutes of class to start searching for their research articles. Anything they do not finish at the workshop will be their homework, i.e. if they do not find an article by the end of the workshop (which is fine), they must find one for homework.
3. Go around the room as they work and try to give them one-on-one support as needed.

(5 min)

4. Last reminders: emphasize that students must find and print an article by the next workshop and bring it with them. Ask if there are any questions.

# ENG Lesson 10: Graphs & Data

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students should know when a bar graph is more appropriate than a line graph, or when to use a certain statistical graph such as a box plot or a distribution curve
- LO2: Students should understand the importance of accurate graphical representation when presenting their findings or looking for significant findings.
- LO3: Students should be reminded of the importance of adding labels, keys, units, etc. to graphs and diagrams

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Primary research papers (brought by students)

**Introduction (5-10 minutes):**
1. The introduction for this workshop is mostly to prepare for the final two weeks of ENG workshops, rather than for this workshop specifically. Students were asked to find a primary research article that they found interesting to use for the next couple weeks, so check with the students to see who found an article. Someone from the ENG program (Outreach Programs) office will be checking each article to make sure it is a good choice for the next couple weeks and will have extra articles on hand.
2. While articles are being checked, ask the students to share a quick summary of the research article that they found and why it interests them. Also ask the students what challenges they had when searching for research articles.

**Activity 1 (25 minutes):**
Students are likely familiar with various types of graphs and how to read them — however, they may not be aware that certain graphs are inappropriate in certain circumstances, even though they may display the same data.

(15 min)
1. On the chalkboard, write the following statements (without the answers in parenthesis):
    - The change in temperature over time (Line graph)
    - Presidential election results (column or bar)
    - Amount of servings from each food group in one day (pie chart)
    - Height and weight of a group of people (scatter plot)
    - Likelihood of 4 consecutive coin flips (bell curve or box plot)
    - Amount of servings from each food group in one day across different age groups (multiple pie charts or stacked columns)

2. Then, for each statement, ask a student to come up to the board and draw a graph that could represent this data. For all of these, be sure to stress that titles, axes and/or keys, and units are always necessary, no matter what graph you use.

(10 min)

3. Also stress the difference between smooth and jagged line curves. Put this image (http://i.stack.imgur.com/HLvBS.png) on the board and ask the students which graph is more accurate of scientific results. Students may be tempted to say that the curved line is more accurate, but the jagged line that connects points with a straight line is more accurate.
4. Ask the students why. In most cases, neither is appropriate, and it depends on how the data was collected. A curved line would imply that you were able to measure continuously (in this case, you were able to constantly measure time and temperature without any breaks, essentially having an infinite amount of data points). A jagged line might appear more accurate, but each line is technically a representation of data values between two points, so jagged lines are not usually good graphical representations.
5. In many cases (especially for simpler graphs that these students will likely be working with in the near future), the best bet is to not have a line connecting all of the points, but to include a trendline that averages all of the points.

**Activity 2 (20 minutes):**

The next activity will involve expanding on the typical graphs that students might see in Excel or statistics programs and observing some more creative graphs and charts used in academic research.

(10 min)

1. Pull up the following image on the projector (this comes from a paper the students looked at briefly in a previous workshop)

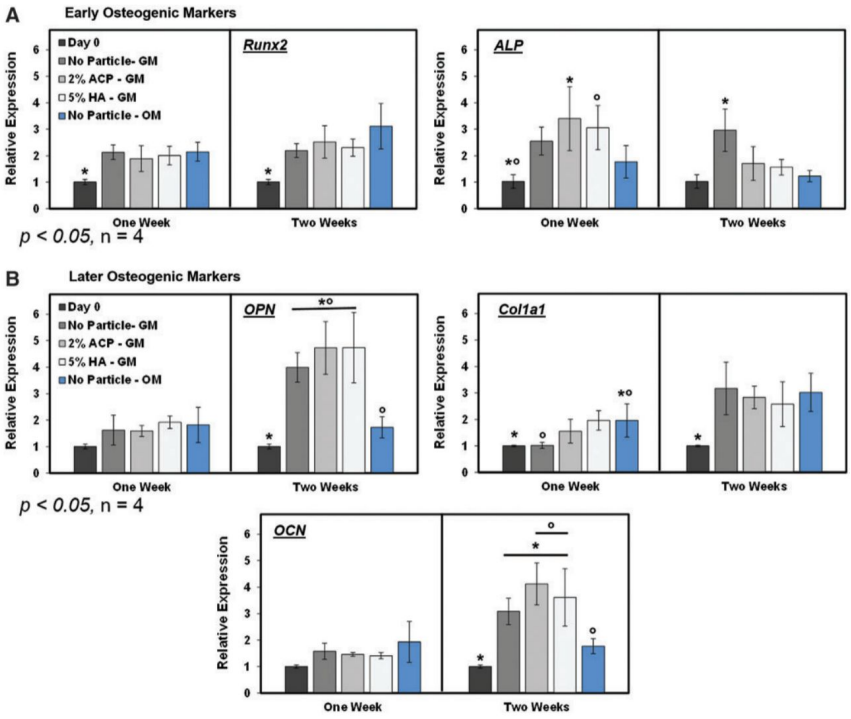



**FIG. 7.** Gene expression of early and later stage osteogenic markers in growth media and osteogenic media through 2 weeks relative to day 0. hMSCs were cultured on polyHIPEs with no particles, ACP, or HA in growth media (GM) and no particle control polyHIPEs in osteogenic media (OM). **(A)** *Runx2* and *ALP* expression, **(B)** osteopontin (*OPN*), collagen type I (*Col1a1*), and osteocalcin (*OCN*) expression. * indicates significance between marked with an asterisk or all other groups in the case where only one group is marked. o indicates significance between groups marked with the same symbol (o). Color images available online at www.liebertpub.com/tea

2. Ask the class the following questions:
    - What type of graphs are these?
    - What does each column or bar represent? (You do not need to know exactly what the treatments do, just know that each are different treatment groups)
    - Why is the bar graph the most appropriate in this case?
    - What are the lines or brackets on each column?
    - What do the asterisks and circles mean?

(5 min)

3. Now try something a little more challenging:

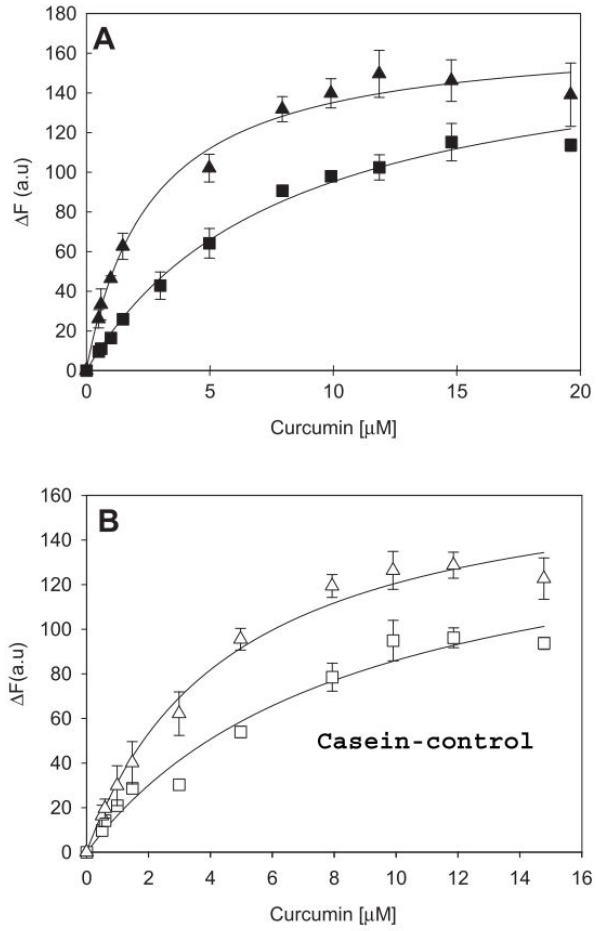



**Fig. 3.** Changes in fluorescence intensity (measured at $\lambda_{em}$ 520 nm), as a function of concentration of curcumin for (A) skim milk (■, ▲) and (B) casein micelles (□, Δ) isolated from skim milk and rediluted in permeate. Samples were unheated (■, □) or heated at 80 °C for 10 min (▲, Δ). Values are the average of three replicate experiments, bars represent standard deviation.

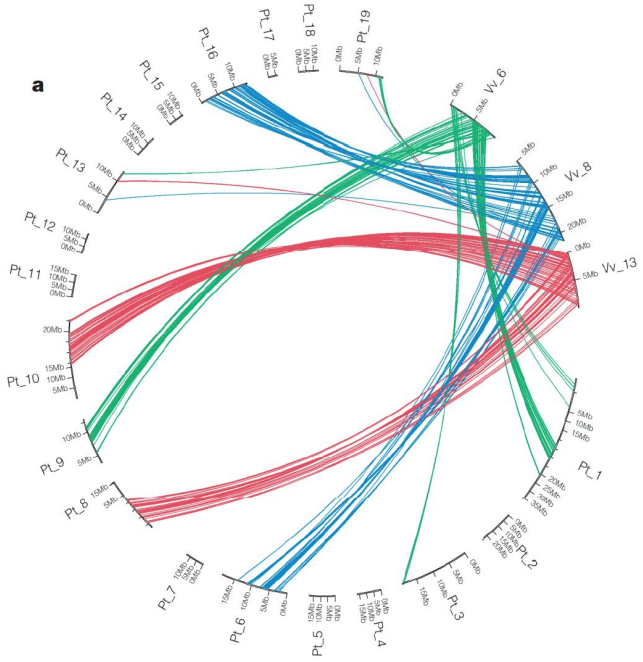
Source: Heating of milk alters the binding of curcumin to casein micelles. A fluorescence spectroscopy study

4. This graph may look complex at first, but by asking similar questions as before, it will be possible to interpret this graph just as easily. Ask the following questions:
    - What type of graph is this?
    - What do the axes mean? (If students are stuck, remind them to read the description. Answer: change in fluorescence intensity for the y axis amount of curcumin for the x axis)
    - What is the difference between the triangle and the square?
    - What is the difference between the black and white shading?
    - What does the trendline show?
5. Share an explanation of this graph: Curcumin is a compound found in turmeric which is expected to have health benefits. A common home remedy in Indian household medicine is to mix turmeric in warm milk and drink it. It is known that casein micelles (found in milk) bind to curcumin and increase curcumin's bioavailability, but this experiment tested whether other factors of milk increase curcumin's bioavailability (measured by the change in fluorescence intensity). This graph confirms that increasing the temperature increases the

bioavailability of curcumin in both the control group (diluted casein) and the skim milk-curcumin mix.

(5 min)

6. Note that sometimes, graphs (such as the one below) are simply not going to be easy to interpret without specialized knowledge:




7. For fun, you can ask the students what they think this graph represents, but they shouldn't be expected to know (it is a comparison of 3 grape vine chromosomes (Vv) to a poplar-grape genome (Pt), and the general 2:1 relationship in the bands shows that a genome duplication event occurred in the poplar-grape genome after these two similar species diverged).
8. Emphasize that graphs can be complicated, but most graphs will stick to the typical layout with which you are already familiar. Tell students to always look at the supporting information on the graph (axis, keys, descriptions, etc.) before jumping to any conclusions about the data. As they become specialized in a particular field, they may learn about more complex graphing methods that better explain their data.

**Wrap-Up/Homework Assignment (5 minutes):**

1. Ask each student to list one thing that they learned from this seminar, then ask if anyone has any lingering questions.
2. Remind students that tomorrow, they will be attending the REU Research Symposium, where REU students will be displaying their posters and PPT presentations. Next week's workshops also focus on presentations, so encourage students to take careful notes (consider adding a worksheet with questions to think about while visiting posters) while they are walking around.

# ENG Lesson 11: Science/STEM Communication

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to list key tenets of science communication (e.g. clarity, adjusting content to fit audiences, etc.)
- LO2: Students will practice summarizing then verbally communicating complex scientific ideas to different audience levels.
- LO3: Students will apply strategies for audience engagement and public speaking (e.g. audience-appropriate examples, anecdotes, etc.)

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Primary research papers (selected by students)
- Slideshow

**Introduction (10 minutes):**
1. Put this quote on a slide and ask a student to read aloud:

   *"For scientists and physicians working today, the ability to communicate is not an important skill; it is an essential skill. They must be able to communicate their research clearly, concisely and accurately not just to funders and peer reviewers, but to colleagues, patients, and the public at large.*

   *They must not only explain the latest findings from the laboratory or clinic, but convey the underlying passion, excitement, and resourcefulness that produced those discoveries. And they must do all this while also learning how to achieve critical distance from their own field in order to become reliable, trustworthy commentators."*
   (https://journalism.nyu.edu/about-us/science-communication-workshops-nyu/)
2. Give students different excerpts on a scientific topic (e.g. the digestive system). If possible, prepare enough excerpts for students to work in pairs. Ask students to read the excerpt and note what the main points are. Tell them that they will practice communicating their information to each other, and then the class. Have them discuss with their partner what the main points might be, and how they might structure what they are talking about.

**Activity 1 (15 Minutes):**
Preparation: Create a slideshow in which you share key points of science communication, e.g. giving a broader context, explaining the why (what's the importance of this topic?), connecting with your audience, adjusting content for your audience's "level"/interests/needs, being

present, etc. If needed, refer to the REU packet on STEM communication. (http://www.nisenet.org/download/nise_product/node/field_download_link/356/0).

1. Present your slideshow. Have students help read the slides and give examples of each facet (e.g. for “being present” that might include making eye contact, body language, tone, expression, not checking your watch, etc.). (10 min)
2. Model/give a sample (2-5 minute) science talk on any science topic. Make sure your example that you model is related to the students and appropriate for the audience. For example, if you discuss your research, give the broader context, make students connect to it, then narrow it down to your specific field. Use analogies or descriptions to help the students understand. Remember, you are presenting your topic to high school students, and they should be able to explain your talk to someone else. (5 min)
3. Student pairs will work together to then hash out their broader context, how they want to connect with the audience, what key points they want to make, how they will phrase these key points, etc. (15 minutes)

(20 min)

4. Students should practice their presentations for 5-10 minutes. Each talk can be 1-2 minutes long.
5. Students will present their brief talks (2 min per group).

# ENG Lesson 12: Presentation Skills — Poster Presentations

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will discuss the purpose of having a poster and when poster presentations are used.
- LO2: Students will draft a poster, with all the relevant information about their research project, summarizing the results, and presenting the findings.
- LO3: Students will practice presenting their entire poster, including a brief introduction, content explanation, and conclusion.

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Primary research papers (selected by students)
- Slideshow

**Introduction (5-10 minutes):**
3. Students should have attended the REU research symposium last Thursday, and will have been encouraged to take notes while attending. Ask the students to write down on a sheet of paper their favorite presentation from the fair and at least three things that they liked about the poster and three things they might have changed about it.
4. Have everyone in the room share with the class what they wrote down.
5. Ask the students how the posters at the REU symposium differed from posters they have used in science fairs. Ask them why they think the format might be different

**Activity 1 (15 Minutes):**
1. Preparation: You will need to prepare two quick slideshows with background information on academic posters and poster presentations (feel free to use information from this link, but do not use the entire presentation as it is rather long: http://hsp.berkeley.edu/sites/default/files/ScientificPosters.pdf).
    a. Overall, the first presentation should last no more than 10 minutes, as students will become less attentive if it is much longer.
    b. The first presentation should cover:
        - The purpose of scientific posters
        - Everything the poster needs to include
        - Typical layouts/how to utilize space effectively
    c. The second PowerPoint should include objectively bad poster presentations (5-10 examples)
2. Show the first presentation and cover the basic topics. Ask if there are any questions.
3. Show the second PowerPoint. Ask the students after each example to discuss why the poster is bad and what they would do to improve it.

**Activity 2 (25 minutes):**

(10 min)

1. Now that students have a clearer idea of the purpose of scientific posters and the qualities of a good or bad poster, they will try to make one on their own. Have the students pair up and plan a poster on a sheet of paper.
2. For the material, each pair should use one of the papers that they selected in the previous week to read. Students do not need to write out much information, but they do need to understand the key points or takeaways from the paper and ensure that they are in key locations on the poster.

(5 min)

3. Once students have planned it on paper, have each pair draw their poster on the chalkboards in the room. (3 minutes)

(10 min)

4. Ask each team to do a quick summary of their poster, noting why they chose to organize their poster in the way they chose based on their paper

**Wrap-Up/Homework Assignment (10 minutes):**

As a wrap-up activity, write a list of qualities that make a good poster display on the board. Each student should contribute at least one item to the list. Share this list at the end of the class via email (or as someone from the ENG program to send the email) so that students have it as a reference as they prepare their own poster presentations.

# ENG Lesson 13: Presentation Skills — PowerPoint Presentations

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to identify the key differences between a poster and a powerpoint presentation and the advantages and disadvantages of each.
- LO2: Students will discuss the best practices of creating powerpoint slides and understand what information should and should not be included.
- LO3: Students will be able to identify key strategies for presenting their powerpoint including body language, eye contact, vocal projection, content, and confidence.
-

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Primary research papers (selected by students)
- Slideshow

**Introduction (5 minutes):**
1. The previous workshop focused on poster presentations, so start with a compare and contrast activity on PowerPoint vs. poster.
2. Draw a large Venn diagram on the board and label the two circles “Poster” and “PPT”.
3. Ask the students provide similarities and differences. Refrain from adding anything yourself unless the class is not cooperating, in which case you should call on students to contribute.
4. Possible answers:
    a. PowerPoint: Usually larger audience, longer presentations, require a presenter, information given out in slides instead of all at once
    b. Poster: For broader audiences/fairs, should be stand-alone, short presentations, all information immediately apparent
    c. Both: Present findings from research, use images to convey information, both have a “flow”, both should be visually pleasing

**Activity 1 (20 minutes):**
(10 minutes)
1. Ask the students what they think makes a good PowerPoint presentation. Have the students contribute at least 5 points. Write them up on the board.
2. Then play the following YouTube video: https://www.youtube.com/watch?v=i68a6M5FFBc
3. Ask the students what they took away from that video and add on to the list that you began before the video.
4. Follow up by asking whether or not all of the statements on the board can apply to science/poster presentations (the answer should hopefully be yes). Even concepts such as storytelling can apply to scientific presentations and can often make them more engaging.

(10 minutes)

1. There are also many technical qualities that make or break a PowerPoint. Create a series of PowerPoint slides that are objectively bad (e.g. too much text, poor color choice, images that don't make sense, etc.). Or, use this one: https://www.apa.org/gradpsych/2012/01/worst-powerpoint-ever.pdf Go through each slide and ask the students what they see as being wrong in each of these slides.
2. Share other important notes about PowerPoint presentations:
    - NEVER read word for word from a PowerPoint. The PowerPoint is a guide - it is not your end-all-be-all document.
    - For scientific presentations, it's usually helpful to provide an outline at the beginning.
    - Transitions between slides should either be completely ignored or barely noticeable.
    - PowerPoints are often shared after a presentation, so if all of the information is not on the slides, add your comments in the notes section on each slide.
    - Stick with a simple design; advanced designs may not load correctly on all computers. In the same vein, make sure your PowerPoint file is compatible with older file types.
    - PowerPoints should be organized and cohesive — each slide should be a natural transition from the previous slide.
3. Tell students that when people present PowerPoints, it is quite clear who has given their presentation its due diligence and who has not. In other words, it will be clear whether or not they have practiced.
4. Remind students to keep in mind:
    - Who is the audience?
    - Are they already aware of this research, or do they not have any contextual knowledge?
    - What are their interests? What would they find interesting?
    - What is the desired outcome of this presentation?

**Activity 2 (20 minutes):**

1. Split the class into 3 groups. You (the presenter) are a business interested in adding a new invention to your product line. Your company has a wide range of products focused on sustainability and environmental health, and you are interested in adding something new that advances sustainability, however you are only able to add one new product to your company.
2. Each group must create a 2 minute pitch to give to the rest of the class. Each presentation needs to address the following questions:
    a. What is their new invention/product?
    b. How did they test the effectiveness of their invention?
    c. Why would this product be a good fit for this company?
3. Each group should spend 5 minutes brainstorming an invention to present, and roughly 5 minutes preparing their presentation (give additional time as necessary). Everyone in each group should have a part of the presentation to present.
4. Afterwards, thank the students for presenting (no need to pick a winner) and recap what went well in the presentations and what could be improved. Remind students to think about who they are presenting to, and how that should affect their presentations. For instance, a

presentation to a company selling a product should have a very different tone than a presentation of the same product to a panel of engineers.

**Wrap-Up/Homework Assignment (10 minutes)** (Skip this if you are short on time — just briefly summarize a couple key takeaway points yourself)

1. As a wrap-up activity, create a google document for helpful tips to keep in mind when preparing and delivering PowerPoint presentations. Require each student to contribute at least one (if not more) item(s) to the list while you are in the classroom. This sheet will be shared with them after the workshop so that they can use it for their research.
2. Go through the presentation rubric that the students have for their final presentations next week.

**Additional Resources:**

http://www.biosurvey.ou.edu/swan/PowerPointGuidelines.pdf

# ENG Lesson 14: Pathways to Careers in STEM

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will review details and ask questions about the different pathways to professional careers in STEM.
- LO2: Students should be able to identify important skills gained from studying STEM fields that can be applied to any career.
- LO3: Students will create a Professional Development Plan for their careers in Science.

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk

**Introduction (5-10 minutes):**
1. Start this workshop by asking the students how many of them have thought about what career they want to pursue after college. Almost all of them are preparing for college admissions, but not all of them may have begun thinking about careers. Ask them to take 3-4 minutes and brainstorm a list of careers in engineering, and then reconvene and have the students share their answers.
2. If you ask them verbatim to brainstorm “careers in engineering”, you’ll likely get a lot of academic answers, and you can take this opportunity to say that careers in engineering expand far beyond just academia, and should provide a nice segue into the next section.

**Activity 1 (20 minutes):**
1. Begin a list on the board of skills that you gain from studying engineering. Try to get at least 20 skills on the board, and also try to get everyone to contribute (go around in a circle if you need to). These can be broad (problem solving) or specific (3D modeling), but the important thing is for them to realize how much they can gain from an engineering education. A key takeaway from this workshop should be that you can do almost anything with an engineering degree, whether you go into academia or industry, and even in industry engineering degrees are highly sought after for a wide range of positions.
2. Go around the room again and ask students what their career goals or ideal careers are. Many will likely say something engineering related because they think they have to in this program, so you can also mention that it *doesn’t have to be engineering related* (but you will prove that everything can be related to engineering, or at least related to engineering skills).

3. Write these up on the board next to the skills. Going through each career, ask the class what skills from the list written earlier would be applicable to each of the careers they listed. If there are a lot of careers in academia, include some jobs from industry (e.g. marketing, consulting, finance, etc.).
4. By the end, every job that you listed should be able to use the skills generated from engineering.

**Activity 2 (15 minutes):**

1. The goal for this activity is to show a couple of the common pathways or trajectories for careers in science in both academic and industry. You might want to start this section off by sharing your own story about what you studied as an undergraduate, how that translated then to working in the industry, and why you decided to go to graduate school afterwards.
2. It might help to prepare a quick PowerPoint with flowcharts or diagrams about popular/common pathways to careers in academia and industry. Students likely know that you can do graduate school after undergrad, but may be unclear about the pros and cons of a masters and a PhD.
3. You may also want to cover the difference in the admissions process between undergraduate schools and graduate schools (they already have had multiple sessions on undergraduate admissions, so you can specifically highlight the differences and maybe highlight some undergraduate experiences that may help them prepare for careers in either academia or industry).
4. Consider discussing which careers only require a Bachelor's and which would require a higher-level degree.
5. Initiate an informal conversation with the students about activities that they are interested in and how those might help students prepare for a career in engineering. Ask the students about their other interests outside of school/academics, and see if the students can identify ways in which those interests are related to engineering, or vice versa.
6. Students should not feel that they have to dedicate their entire lives to something related to engineering, but they should be able to see that engineering can be related to almost anything they want to do, and even some of their non-engineering activities can benefit or supplement their engineering education.

**Wrap-Up/Homework Assignment (10 minutes):**

1. As a wrap-up, ask the students whether they have a better understanding of possible steps they can take to prepare themselves for a career in engineering. Ask if they have any questions related to this topic.
2. Ask a few students if they can share an activity or interest that they plan to pursue in college outside of the classroom that might help them prepare for a career in STEM.
3. In preparation for the last two workshops, remind the students to bring printed copies of the academic paper they have been reading to the next two workshops.

# ENG Lesson 15: Writing an Abstract

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to describe the typical format and purpose of an abstract.
- LO2: Students will practice summarizing their research in a condensed format.

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk

**Introduction (5-10 minutes):**
1. Begin by asking the class if someone can define the word abstract. The word 'abstract' comes from the latin word 'abstractus' meaning 'draw away', which comes from two latin roots: 'ab-' meaning 'from' and 'trahere' meaning 'draw off'. So, a science abstract draws out the important aspects of a longer paper.
2. Tell the students that more often than not, readers are not going to read a paper fully, and will rely on the abstract to get the essential information. This is similar to an executive summary on a report in any business - the full report has all the details you could want, but the important people reading the paper do not have the time to sift through it.
3. Ask the students what they think are some important details/information that need to be included in the abstract. Write them up on the board, and add/remove as necessary.

**Activity 1 (20 minutes):**
(3-5 min)
1. For this section, it might be helpful to prepare a short PowerPoint (5 minutes max) or something to go over the basic concepts of writing an abstract. Feel free to use this link (http://writing2.richmond.edu/training/project/biology/abslit.html) as a starting point for reference. After the presentation you will do a short activity where students analyze a bad abstract and a good abstract.

(5 min)

2. Put abstract sample 1 up and ask a student to read it aloud:

> Sample 1: This experiment will determine what will make enzymes effective and what will make them ineffective. We tested different samples of enzymes in a spectrophotometer and recorded their absorption rates. Six samples were placed in the spectrophotometer but two contained no enzyme; these acted as blanks for the other samples. The four remaining samples contained Catecholase ranging from 0.5 ml to 1.75 m. The second half of the experiment contained four test tubes with a constant amount of Catecholase, but the pH levels ranged from four to eight. It was found that if the enzyme was present in large amounts, then the absorption rate was high, and if the pH level ranged from 6 to eight then the absorption rate was high. Therefore it can be said that enzymes work well in neutral pH levels and in large amounts.

3. Ask the students what they think about this abstract. Is it good? What are some of its problems? Have the students write down their criticisms and then go around the room and ask people to share what they came up with.

(5 min)

4. Now show the students a better written abstract from the same paper.

> Sample 2: This experiment was performed to determine the factors that positively influence enzyme reaction rates in cellular activities since some enzymes seem to be more effective than others. Catecholase enzyme activity was measured through its absorption rate in a spectrophotometer, using light with a wavelength of 540 nm. We compared the absorbance rates in samples with varying enzyme concentrations and a constant pH of 7, and with samples with constant enzyme concentration and varying pH levels. The samples with the highest enzyme concentration had the greatest absorption rate of 95 percent compared to the sample with the lowest concentration and an absorption rate of 24 percent. This suggests that a higher concentration of enzymes leads to a greater product production rate. The samples with a pH between six and eight had the greatest absorption rate of 70 percent compared to an absorption rate of 15 percent with a pH of 4; this suggests that Catecholase is most effective in a neutral pH ranging from six to eight.

5. Ask what makes this abstract better than the previous one.
6. Use information from this page (http://writing2.richmond.edu/training/project/biology/abslit.html) to read more about why certain elements of both abstracts are good and bad. Pull out the key points and share them in the PowerPoint.

(5 min)

7. Lastly, ask the students to pull out the papers that they have been using this past week (each student has a different paper). Ask the students to read over the abstracts and note the various sections in the abstract (Intro/purpose, method, results, conclusion). Also have students circle keywords in their abstracts and underline words that they do not understand.

8. Give the students about 5 minutes to do this, and then regroup. Ask the students for their thoughts: Was it difficult to determine the sections of the abstract? How much of the abstract was spent on each section? Did the abstract define any key terms? How much of the abstract was too technical to understand?
9. Also ask the students to compare the abstract from their paper to the good and bad examples you used earlier. Was their abstract good, or could it have been improved in certain ways?

**Activity 2 (20 minutes):**

1. Now it is time for students to write "abstracts" for their own research projects (or more accurately, glorified elevator pitches). The purpose of this exercise is to help students realize the challenges of summarizing their research in as few words as possible while keeping it accessible to those not specialized in their field of study.
2. Print out sheets to pass to the students to work on with the following questions:
    - What is the purpose of this experiment?
    - What was the hypothesis?
    - What were the constants and controls in this study?
    - What were the independent and dependent variables?
    - How were the independent and dependent variables measured?
    - What were the results (or what are the expected results)?
    - Why is this research important?
3. These questions should help the students extract the salient points from their research experience.
4. Next, ask the students to write an abstract or summary on the back of these sheets for their research. It must be 75 words or less and incorporate most (if not all) of the information on the front side of the sheet.
5. Once students have finished writing their abstracts, have each student read their abstract, and after each one, ask the rest of the class what they thought of the abstract (i.e. do the other students understand and have a decent grasp of this student's research?) Make sure the feedback is constructive.

**Wrap-Up/Homework Assignment (10 minutes):**

Ask the students what they found most difficult about writing their abstract or short summary. See if the class is able to offer any suggestions or answers to those questions, and be sure to offer your own thoughts as well.

**Additional Resources:**

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3136027/

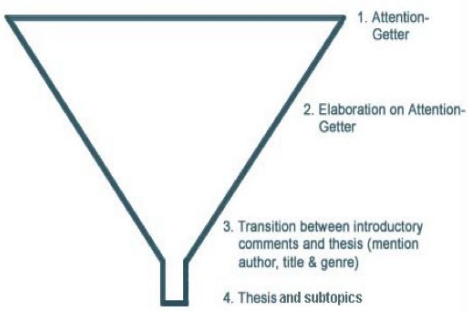
# ENG Lesson 16A: Turning Your Research into Articles — Introductions and Conclusions

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students will be able to describe how the methods and results sections are related.
- LO2: Students will be able to distinguish the difference between the results and conclusions section and know what information is appropriate for each section
- LO3: Students will discuss the importance of providing precise and reproducible instructions in the methods section.

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Academic paper(s)

**Activity 1 (20 minutes):**
(10 min)
1. The goal for this is activity is to help students understand how even very specific research projects that may not appear important at first are actually crucial to the larger picture of scientific research.
2. Begin this workshop by asking students what they believe is the purpose of the introduction. Clarify that this section is more than just providing background research; it is also supposed to set the stage for their research. Research papers often focus on a very specific topic that most people cannot relate to, so introductions have to make their research more relatable to a broader topic.
3. Show the students an introduction of a paper that you are familiar with (you can copy and paste each paragraph onto slides of a PowerPoint and ask students to read it out loud to the class).
4. Ask the students to give a quick one-sentence summary of each paragraph in backwards order. Ideally, the first paragraph of the introduction (aka the last one being summarized) will discuss the larger-picture for the paper, so ask the students what the topic of the paper is and why it is important. E.g. If the paper was researching the design and shape of airplane wings, you could say it would help improve airplane design, which could improve speed, which could reduce travel time, which could result in less airplane delays and better travel experiences
5. Then, ask the students why you went through the paragraphs in reverse order. Put the following image on the board and briefly discuss the funnel structure and why this structure is ideal and efficient for introductions.




(10 min)

6. Now that you have worked through an example with the class, let the students try to do one on their own. Ask the students to read the introductions of their own papers (they should have already looked through it) and summarize each paragraph in 5-10 words, and hopefully see a funnel organization in their own papers.
7. Afterwards, each student should share their summary funnel with the class.
8. You can wrap up this section by mentioning that, for research to be funded, people have to make the connection between their research and its importance to society. If you can't talk about how your research will have a larger impact on the world, no one will give you the money to do your research.

**Activity 2 (20 minutes):**

(5-7 min)

1. This activity will focus on the conclusion. Draw the parallel that the conclusion is almost the opposite of the introduction — you start out by discussing the immediate implications of your research to the specific question the experiment addressed, and then expand to discuss the broader implications.
2. Mention that conclusions often end with a suggestion or recommendation for future research, and it is important that even these high school students discuss future plans in their own research, especially as many of these students will not have finished their research projects.
3. Give the students 5-7 minutes to reread the conclusion sections of their papers (they should have already read the paper in full). Ask the students whether they see any pattern or trajectory in the paragraph structure: Does the conclusion section 'funnel out' as discussed, or does it take an alternative method? Does it end with a recommendation for future actions?

(10-13 min)

4. Finally, ask the students to think about their own research projects and how their research fits into "the big picture." Ask the students to plan out their own introduction sections (aka a topic sentence for each paragraph they would include) and conclusions, and share with the class.
5. Consider having students write their introduction outlines on the board to help people visualize the funnel structure.

**Wrap-Up/Homework Assignment (10 minutes):**

Ask the students to each share something they learned in this workshop. Allow time for any questions they may have. Remind them to bring their research papers to the next workshop as well and tell them that the next workshop will be focused on methods and results.

**Additional Resources:**
http://www.sciencebuddies.org/science-fair-projects/project_conclusions.shtml

# ENG Lesson 16B: Turning Your Research into Articles — Methods and Results

**Date:**
**Facilitator:**
**Duration:** 60 minutes

**Learning Objectives:**
- LO1: Students should be able to communicate how their specific research project relates to larger, more general scientific goals.
- LO2: Students will receive information about the funnel structure for introductions and conclusions and will discuss why the funnel structure works.
- LO3: Students will be able to give reasons why publications are important to both the scientific community and to careers in science.

**Materials & Supplies:**
- Laptop/computer
- Projector
- Whiteboard/chalkboard
- Marker/chalk
- Academic paper(s) from previous workshop
- 20-30 statement paper strips (see activity 1, number 4)

**Activity 1 (20 minutes):**
(10 min)
1. Contrary to the title of this workshop, the first activity will be about the results, not the methods.
2. Start out by asking the students what they think the difference is between the results and the conclusions. While there is certainly debate on this, the results section usually explicitly states the quantitative and qualitative observations made from performing the method, while the conclusion section attempts to explain what the results mean. This is not always the case, and in many papers, the conclusion section is usually just one paragraph with the important takeaways, and some of the explanation of the data is included in the results section rather than the conclusion.
3. You should note that it is important to check the website of journal publishers to see if they have requirements for what to include in results or conclusions, as different journals may have varying requirements.

(10 min)
4. Pre-workshop preparation: Create a list of 20-30 statements that could appear in either a results or conclusion section (preferably pull these from real primary research article but any will do). Print these out and cut them into strips.
5. Before starting the activity, put some statements in the PowerPoint and go through a few examples of results vs. conclusions as a class.
6. Next, break the class into pairs and pass a few statements out to each pair. Ask the pairs to decide whether each statement should go in the results section or in the conclusion (or if they could go in both). Go around the room as they work to make sure they are on track.

7. Have each group read their statements and share which section they put them. As a class, make sure these classifications are correct.

**Activity 2 (10 minutes):**

1. Results are also where most graphs and figures are located. The students have already had a workshop dedicated to analyzing graphs and data, but it would be helpful to bring it up again for a brief discussion.
2. Ask the students to go through the papers again and look for any graphs or pictures that were included. Have them think about answers to each of these questions: How many graphs were included? How many data tables? Were there any images or photographs? Any diagrams or flowcharts? Ask 1-2 students to share their answers.
3. Mention that papers in different fields are likely to have different amounts or types of images or graphs; for example, a computer science paper (one student has this) might have more flowcharts but zero images, while a biomedical engineering paper might have more photographs.
4. Next, ask the students to analyze the graphs in their paper — do they make sense? What are the graphs summarizing, and do they effectively summarize the important results of the paper? Are there any results that were written in the paper but did not reference a graph or data table?
5. Go around the classroom and ask each student to briefly share
    a. What images/graphs/diagrams were included in their results section
    b. Were the images/graphs/diagrams effective at showing visually the most important takeaways from the paper or were they unclear/ineffective/unnecessary?

**Activity 3 (20 minutes):**

(5 min)

1. Mention the following briefly: The methods section is likely formatted differently in each paper, and students should already be aware of this after completing the primary research workshop. Shorter academic papers have been favored recently in many journals, requiring methods sections to be concise and removing extraneous steps. Often a helpful tip for writers is to take the results they have included in their paper and work backwards, only including the steps necessary to reproduce the data included.
2. First, ask the students to share how the methods are presented in their paper. Is it at the end of the article, does it come after the introduction, etc.?

(10 min)

3. Ask the students to go through the methods and, with a pen or pencil, mark off each section of the methods that produced each set of results in the results section. Some papers may already be organized in this fashion, but hopefully the majority is not. Move around the room as they work to make sure they understand the task.
4. Ask students to share if there were any sections of the methods that could not be traced to the results and ask whether or not that section of the methods is necessary.

(5 min)

5. Lastly, the methods section is a prime spot for many academic critics; after all, if the experiment is not designed properly, whatever results that are produced will be mostly meaningless. Ask the students to look at their methods section again and see if they have

any criticisms — did the methods match the results that they produced? Did they have control groups and control for variables they weren't testing?

6. Students will likely not find many problems or might have difficulty criticizing a paper. Tell them that this is fine because these papers were already peer-reviewed and published. However, encourage students to be critical when reading the methods section to see if there were better ways of designing an experiment.

**Wrap-Up/Homework Assignment (10 minutes):**

Go around the room and have each student share an important takeaway from the past two days. Ask if they have any questions.