**Supplemental File S1- Student materials**

**Communicating Science**

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## INTRODUCTION

**The importance of communicating science with the general public**

Communicating science with the general public (abbreviated as SciComm) is an important activity that scientists do for several reasons. Scientific findings can help improve life, but the public must be aware of and trust the science to take actions that allow them to benefit. For example, in order to protect children against debilitating yet preventable diseases, parents must take their children to get immunizations. However, if a parent doesn’t understand the science of vaccines and/or doesn’t trust that the scientific community has their best interests in mind, they may not have their children vaccinated, putting them and the community at risk. Therefore, it is important that science is communicated effectively to the general public.

## How to effectively communicate science with the general public

Social scientists are currently studying the best ways to communicate science with the general public. In order to create effective SciComm, you must carefully consider a number of elements when planning and executing your SciComm. This includes defining the purpose of your communication, or why you’re doing it. A ubiquitous goal of all science communication is increasing awareness and knowledge. However, this should not be the only goal. Other important goals include boosting interest and excitement, conveying competence, conveying warmth and respect, reframing issues, listening and demonstrating openness, and conveying shared values.

The goals of your SciComm project will be to

* Increase awareness and knowledge of a scientific topic
* Boost interest and excitement about science

Both goals are important when trying to effectively communicate science to a non-scientific, general public audience. To increase awareness and knowledge, think about sharing what you know and why it’s important rather than filling a gap in someone’s knowledge. To boost interest and excitement, customize your communication to make it interesting to your specific audience.

Besides setting goals, research has defined a number of other elements to carefully consider in order to create effective SciComm. These elements are listed in Table 1 and are described below. For your assignment, you will explicitly address each element either in your SciComm or the associated worksheet. The expanded definitions below include questions to ask yourself when planning your SciComm.

**Table 1.** Important elements for effectively communicating science with the general public.

|  |  |  |
| --- | --- | --- |
| **Category** | **Element** | **Task** |
| Why | Purpose\* | Identify the purpose and intended outcomes (goals) of the communication. |
| Who | Audience | Identify and understand a suitable target audience. |
| What | Content\* | Focus on a small amount of scientific information. Separate essential from non-essential factual content in a context that is relevant to the target audience. |
|  | Prior Knowledge | Consider the levels of prior knowledge in the target audience. |
| How | Language | Use language that is appropriate for your target audience. |
|  | Style | Use appropriate and impactful stylistic elements (e.g., humor, story). |
|  | Appeal | Appeal to the senses. |
|  | Engagement | Promote audience engagement with the science. |
|  | Dialogue | Encourage two-way dialogue with the audience. |
|  | Mode\* | Use a suitable mode to communicate with a target audience. |
| Where | Platform\* | Use a suitable platform to communicate with a target audience. |

Adapted from Mercer-Mapstone and Kuchel, 2017, IJSE 7:2, 181-201, DOI: [10.1080/21548455.2015.1113573](https://doi.org/10.1080/21548455.2015.1113573)

\*Elements that are provided for you.

The **content** you will share with the general public needs to relate to the role of macromolecules

 in living organisms. Macromolecules is a broad topic that you will need to narrow down. What you decide to focus on is up to you and may depend on the other elements of the SciComm. Let’s discuss these other elements and come back to what content to include.

A very important step in planning your SciComm, is determining who you are trying to reach with your SciComm, your **audience**. This decision will inform many of the decisions to follow. To identify and understand a suitable target audience, answer the following questions:

* Who might be interested in your topic?
* Who do you have access to?
* Who do you think should know about your topic?

Below are three choices to help narrow your audience. Choose one as your audience to complete this assignment.

1. 7th grade students
2. Retirement home residents
3. Classmate or co-worker not studying or working in science

Now that you have an audience in mind, next you will determine specifically what to include in your SciComm. Although you’ve already been given a general topic, you will need to narrow down the specific **scientific content** you will share in your SciComm. To help you determine what content to share, consider the following questions:

* How can the general topic be broken down into smaller topics? How can those smaller topics be broken down into even smaller topics? You could create a concept map of topics to help you visualize this.
* What do you know particularly well?
* What do you think is especially important?
* What information is essential to share in order to achieve your goals?
* What information do you think is relevant and may be interesting to your target audience?

Another element to consider when determining what content to share in your SciComm is what your audience already knows, called **prior knowledge**. To help direct what content to share, consider the following questions:

* What might your audience already know about this topic?
* What might your audience want to know about this topic?
* How do you know what your audience knows?
* How will you find out what your audience knows?

Now that you’ve defined what you will communicate and to whom, let’s consider h ow and

 where you will communicate science with the general public.

The **mode** of your communication is the type of tangible item. Common examples include podcasts, videos, infographics, art, live interactions, or a combination of these. For this assignment, you will create a 1-page (8.5” x 11”) infographic.

The **platform** is where you place your SciComm for public access. Examples include at a museum, in a classroom, on social media, and on YouTube. For this assignment, you will only be sharing your SciComm with the instructor through a Blackboard submission. However, you will need to describe how you would disseminate your SciComm including what platform you would use in the worksheet. To help determine what platform to use, consider:

* Where can you reach your audience?
* Balance reaching a large number of people with having quality interactions. For example, posting your infographic on Facebook will likely reach more people than hosting an in-person event; however, talking in-person but will likely lead to more engagement and dialogue than a Facebook post.

Next, let’s consider more about how you will communicate science through the elements of language, style, appeal, engagement, and dialogue.

Use **language** that is appropriate for your audience. Jargon is special words or expressions that are used by a particular profession or group and are commonly difficult for others to understand.

You can use jargon, if you think your audience will know it; you may use jargon but provide an accessible explanation of the term; or you may want to completely avoid jargon. Additionally, it is important to consider what language you use outside of jargon. For example, the words you use to communicate with business CEOs will be different than the words you use to communicate with middle school students. To help you decide what language to use, consider the following questions:

* What relevant jargon may your audience know and not know?
* What relevant jargon may have alternative, colloquial meaning?
* What non-jargon language is appropriate for your audience?

In addition to your language, you need to consider what **style** you will use to deliver your message. Different styles include humor, anecdotal examples, analogies, metaphors, and stories. These styles help to convey the personal side of science and are shown to be much more effective than presenting data. Like the other elements, what style you use needs to align with your audience and goals. For example, making an analogy comparing the circulatory system with roads and traffic may not be effective with young children who don’t have relevant experiences to make sense of the comparison. To help you decide what style to use, consider the following questions:

* What stylistic elements will help get achieve your goals?
* What type and number of stylistic elements are appropriate for the audience, mode, and platform?

How your SciComm **appeals** to the senses can also affect the effectiveness. Depending on the setting of your SciComm, consider the following questions:

* If your SciComm includes audio/video, is it of high quality and accessible audience?
* If your SciComm includes text,
	+ Is the spacing even?
	+ Is it in a readable size and font?
	+ Is there a balance of space, text, and images?
* If your SciComm includes a person, is the body language natural and comfortable?
* If your SciComm includes speaking, are the spoken words clear, confident, and an appropriate tone, pace, and volume?

During your SciComm, you should strive to **engage** the audience with science, instead of just having them be in the same space. Museums do this, for example, when they have a sandbox

where patrons can uncover fossils. How might you be able to engage your audience with the science?

Science communication, like other types of communication, should be bidirectional, that is not only from you to the audience, but also from the audience to you, the science communicator. Ways to engage in two-way **dialogue** include asking the audience questions and really listening to responses and asking for questions and feedback. To help facilitate two-way dialogue, consider the following questions:

* How can I encourage input from the audience?
* How will I adapt the content according to audience input?

Engaging an audience with science and participating in two-way dialogue may be difficult to achieve with an infographic (your assigned mode). However, you are encouraged to creatively fulfill these elements; in doing so, you may be awarded bonus points (see Table 2).

Along with deciphering the most effective ways to communicate science with the public, research has identified ineffective ways to communicate science. For example, if an audience is given evidence that is contrary to their beliefs, they commonly dismiss that evidence, even if it is scientifically accurate, and hold onto their original beliefs even more strongly; this is called the “backfire effect.” Therefore, it is important that you plan and execute your SciComm carefully, according to the information provided above and the assignment described next.

## Citing your sources

When creating anything in science, it is important to give proper credit to the sources that you use to create your novel work. For this project, you will give credit to this sources by citing them in the worksheet described later.

## Advice on creating your SciComm

Like other scientific processes, planning and executing SciComm is an iterative process in which a decision about one element can affect several other elements. The specific audience will certainly impact most of the other elements. Therefore, once you’ve decided on one element, be sure to revisit your choices for the rest of the list of effective SciComm elements to make sure they all work together.

## Sharing your SciComm publically

## Many of you will create exceptional infographics and may want to share them with the public. While this assignment does not require you to do so, you are welcome to post work you are proud of to public outlets. It may be ideal to received feedback from your TA about the accuracy, tone, etc. of your infographic before posting it.

## ASSIGNMENT

**Your group infographic and worksheet must be submitted to Blackboard before the start of your lab section during the week of April 1.**

**Your individual survey must be completed before the start of your lab section during the week of April 8.**

**Learning Goals**

By creating a SciComm unit, you will

* 1. Gain a deeper understanding of the role of macromolecules in living organisms
	2. Connect biology content with events in the world outside of the biology classroom
	3. Practice effectively communicating science to a general audience

## Learning Objectives

Upon achievement the above learning goals, you will be able to

1. Describe the structure and/or function of macromolecules in living organisms
2. Implement specific elements of effective SciComm
3. Present scientific information that is clear and concise for a general public audience
4. Present scientific information in a positive and exciting manner

## Instructions

There are three parts to this assignment (listed below). More details are provided below.

1. Infographic - You *and a partner in your lab section* will create a 1-page infographic that communicates science with a general public audience.
2. Worksheet - Your group will describe and reflect on your infographic by answering questions on the associated worksheet.
3. Survey - After submitting your infographic and worksheet, you will take a short survey (on Blackboard) about what you learned during this unit. Each person will complete this survey.
4. *Infographic*

Create a 1-page (8.5 inches x 11 inches) infographic that communicates science with the general public. The following elements are provided for you.

The **objectives** of your SciComm are to

* 1. Increase public awareness and knowledge of the role of macromolecules in living organisms
	2. Boost interest and excitement about science

The **content** of your SciComm will center on something specific about the role of macromolecules in living organisms that you and your partner will determine.

Your **audience** will be from the general public (non-scientist). Choose one of the following choices as your specific audience.

* + 1. 7th grade students
		2. Retirement home residents
		3. Classmate or co-worker not studying or working in science

Your **mode** of communication is a 1-page (8.5 inches x 11 inches) infographic.

The rest of the elements (from Table 1) are for you to determine. Use the information and questions provided in the introduction of this unit to guide you. You will demonstrate each of these elements in your infographic and/or describe them on the worksheet.

1. *Worksheet*

The worksheet will serve three purposes: (a) help you integrate the important elements of SciComm (described in the introduction and Table 1) into your infographic, (b) communicate how and why you’ve addressed the important elements of SciComm the way you have in the infographic, and (c) cite the sources you used to create the infographic.

The worksheet is provided in a separate file. Download and fill out the *one* worksheet for your pair. Upload the completed worksheet as a .docx file along with your .pdf infographic as a part of your Blackboard submission.

1. *Survey*

After submitting your infographic and worksheet, you will take a short survey on Blackboard about what you learned during this unit. You will complete this survey

 individually. To earn any points for this unit, you must submit the survey before the specified due date. No late work will be accepted. Complete the survey before the start of

 your lab section during the week of April 8th, or the infographic and worksheet will not be accepted.

Format

* Your infographic must be submitted to Blackboard as a **.pdf** file
* Your w orksheet must be submitted to Blackboard's SafeAssign as a **MS Word**

## document (.docx).

* Proofread your work to avoid spelling and grammatical errors.
* After you upload your files, **view them** to ensure they were submitted properly.

## Assessment and evaluation rubric

The infographic is worth 20 points and the associated worksheet is worth 10 points totaling 30 points for the group project. The project will be assessed and evaluated with the rubrics below. To receive these points, you must individually complete the survey by the due date.

**Table 2.** Rubric to assess and evaluate the infographic (20 points)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Element | **Unacceptable** | **Poor** | **Fair/Good** | **Exceptional** |
| Content | Has 0 or only 1 feature described under “Exceptional” | Has 2 out of the 4 features described under “Exceptional” | Has 3 out of the 4 features described under “Exceptional” | Includes focused, relevant, and important information. Does not include superfluous information |
| 0 | + 1 | + 1.5 | + 2 |
| Accuracy | The biological information has several inaccuracies | The biological information has some inaccurate portions | The biological information is mostly accurate | The biological information is completely accurate |
| 0 | + 1 | + 2 | + 3 |
| Language | Does not use language that is appropriate for the audience including jargon andnon-jargon portions | Uses language that is somewhat appropriate for the audience including jargon andnon-jargon portions | Uses language that is mostly appropriate for the audience including jargon and non-jargon portions | Uses language that is completely appropriate for the audience including jargon andnon-jargon portions |
| 0 | + 1 | + 2 | + 3 |
| Style | Inappropriately uses stylistic elements or doesn’t use any stylistic elements | Uses appropriate stylistic elements for the audience | Uses appropriate stylistic elements for the audience and that make the product enjoyable **or** relatable | Appropriately uses stylistic elements that make the product enjoyable **and** relatable |
| 0 | + 1 | + 1.5 | + 2 |
| Appeal | Unappealing to the senses and/or has 4 or more noticeable errors | Somewhat appealing to the senses and/or has 2-3 noticeable errors | Mostly appealing to the senses and/or has 1 noticeable error | Completely appealing to the senses and has no noticeable errors |
| 0 | + 1 | + 2 | + 3 |
| Engage- ment (bonus) | Audience does not engage (e.g., is distracted) | Audience passively engages (e.g, listens/watches/reads) | Audience moderately engages | Audience actively engages |
| 0 | + 1 | + 1.5 | + 2 |
| (continued on the next page) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dialogue(bonus) | Communicates at, not with audience | Solicits audience input | Listens to audience input | Listens to and incorporates audience input |
|  | 0 | + 1 | + 1.5 | + 2 |
| Boosts | Conveys a negative | Conveys a positive | Conveys a positive | Conveys a positive |
| Interest and Excitement | or neutral tone | tone | tone that helps relate to the audience **or** is surprising or entertaining | tone that helps relate to the audience **and** is surprising or entertaining |
|  | 0 | + 1 | + 1.5 | + 2 |
| Originality | Copied from another source (plagiarized) | Closely resembles other products | Has few similarities to another product | Completely unique from any others |
| 0 for the assignment and possibly the class | 0 | + 1 | + 3 |
| Size | Larger or smaller than 8.5” x 11” |  | 8.5 inches x 11 inches |
| 0 | + 2 |

**Table 3.** Rubric to assess and evaluate the worksheet (10 points)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Element | **Unacceptable (+0)** | **Fair (+1)** | **Good (+1.5)** | **Excellent (+2)** |
| Audience | Does not answer all items or answers don’t match the infographic | Answers all items but superficially | Thoroughly answers most items and answers all items | Thoroughly answers all items and 100% matches infographic |
| Prior Knowledge and Content | Does not answer all items | Answers all items but superficially | Thoroughly answers most items and answers all items | Thoroughly answers all items |
| Language and Style | Does not answer all items or answers don’t match the infographic | Answers all items but superficially | Thoroughly answers most items and answers all items | Thoroughly answers all items and 100% matches infographic |
| Engagement and Dialogue | Does not answer all items or answers don’t match the infographic | Answers all items but superficially | Thoroughly answers most items and answers all items | Thoroughly answers all items and 100% matches infographic |
| Platform and Sources | Does not answer all items | Answers all items but superficially | Thoroughly answers most items and answers all items | Thoroughly answers all items. Sources in APA |

## Example

## Below is an example of an infographic related to biology to help guide your project. However, it is not necessarily relevant to macromolecules. You are welcome to search for other examples (e.g., Google Images). However, be sure to create something that is unique to you.



**WORKSHEET**

Group Members: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Section: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Instructions.** Answer the following questions about your SciComm project by filling in the purple shaded boxes. Complete one worksheet per group. Upload to Blackboard as a **MS Word document (.docx)** by the due date. The worksheet is worth 10 points and will be evaluated based on the rubric provided in the assignment instructions.

**Audience**

1. Who is your intended audience?
	1. 7th grade students
	2. Retirement home residents
	3. Classmate or co-worker not studying or working in science

|  |
| --- |
| Type choice here: |

1. Why did you choose that audience?

|  |
| --- |
| Type explanation here: |

**Prior Knowledge**

1. What did you anticipate your audience knew about the topic?

|  |
| --- |
|  |

1. How did you identify what your audience knew about the topic?

|  |
| --- |
|  |

**Content**

1. How did you decide what information to include and what relevant information to leave out of your infographic? Include two specific examples, one piece of information that you included and one that you did not.

|  |
| --- |
|  |

**Language**

1. What jargon did you purposely include? List the terms below.

(You may answer “none” if appropriate).

|  |
| --- |
|  |

1. Why did you decide to include this jargon?
(Write “NA” if answered “none” to question 6 above.)

|  |
| --- |
|  |

1. What relevant jargon did you purposely omit? List the terms below if applicable.

|  |
| --- |
|  |

**Style**

1. What stylistic elements did you include?
(e.g., humor, anecdotal examples, analogies, metaphors, stories, none)

|  |
| --- |
|  |

1. Why did you choose these stylistic elements?

|  |
| --- |
|  |

**Engagement**

1. Did you try to engage your audience with the science?

|  |
| --- |
| Yes / No |

12A. If yes, how did you expect your audience to engage with the science?

12B. If no, why did you choose to not try and engage your audience with the science?

|  |
| --- |
|  |

**Dialogue**

1. Did you try to get input from your target audience regarding your infographic?

|  |
| --- |
| Yes / No |

14A. If yes, briefly describe the input you received from your audience.

14B. If no, why did you not get input from your target audience?

|  |
| --- |
|  |

**Platform**

Although you only shared your infographic with the instructor, imagine that you were going to share it publicly.

1. Where would you share your infographic?

|  |
| --- |
|  |

1. Describe why this platform would help reach your target audience.

|  |
| --- |
|  |

**Sources**

17. List the sources you used to create your infographic using APA format.

|  |
| --- |
|  |