BEYOND "GOOD JOB!" - PRACTICING SCIENTIFIC FEEDBACK

KEY TERMS
- Constructive feedback
- Peer review

KEY SKILLS
- Evaluating scientific work
- Giving constructive feedback
- Writing clearly and professionally

GRADE LEVEL
High school

NGSS CONNECTIONS
Practices: obtaining, evaluating, and communicating information

ESTIMATED TIME
Three 45-minute class periods (flexible)

MATERIALS
- Presentation of "Would You Rather?" Activity
- Class set of "Scientific Feedback Examples" student handout (print or upload to LMS)
- Class set of science-related student work ready for peer review (e.g., lab report, research paper, or science fair project)
- Class set of one of our Peer Review worksheets (print or upload to LMS)
- One large whiteboard OR digital bulletin board (i.e., website or app)

SUMMARY

In this lesson, students will identify qualities of constructive scientific feedback. Then, they will practice giving structured feedback on a classmate's science-related work using the qualities they identified earlier. This lesson works as a one-time, standalone activity or as an introductory lesson to prepare students to provide ongoing and systematic peer review throughout a unit, semester, or school year.

LEARNING OBJECTIVES

By the end of this lesson, students will be able to:
1. Identify qualities of constructive feedback
2. Practice giving scientific feedback using a structured approach

PRIOR KNOWLEDGE

This lesson may be easier to facilitate if students have some experience giving peer feedback in at least one of their classes. Before teaching the lesson, consider connecting with your ELA colleagues to see what strategies or language students may already be familiar with for giving their peers constructive feedback.

Students should also be able to identify fundamental parts of the scientific method – for example, types of variables, hypotheses, data, and analyses – and recognize when they are missing, unclear, or used incorrectly.

BACKGROUND INFORMATION

For scientists, the **peer review publishing process** is often the final step of quality control before new research is officially and permanently shared with the world. During this process, scientists who study a similar topic (**peers**) evaluate the authors' research to make sure it was done properly, is clearly communicated, and contributes meaningfully to scientific knowledge – for example, by presenting new ideas or challenging existing ones. Once they receive this feedback, the authors of a manuscript must address the recommended changes before their research can be published. These revisions may be iterative, with authors submitting multiple drafts before their peer reviewers accept the work. Essentially, the peer review process serves as a checkpoint before publishing scientific ideas. When research has been formally peer reviewed, it signals that other expert scientists have judged the work to be ready for publication. The phrase "peer reviewed" is often seen as a stamp of approval.

Outside of scientific publishing, **"peer review"** can be used to describe a wide range of activities centered around giving, receiving, and implementing feedback. For example, scientists may give their colleagues informal feedback as they are designing, analyzing, or writing about their experiments. In a classroom setting, students often use peer review to give one another feedback on a draft of an assignment. For this lesson, students will practice giving structured scientific feedback like scientists give one another during the *peer review publishing process*. Through this practice, students will learn how to evaluate scientific work (including their own) through a critical lens and give professional, constructive feedback.

MATERIAL PREPARATION (only needed for Class Two and Three)

Choosing Student Work for Peer Review

For the peer review activity, students need a draft of a science-related report or project (e.g., a lab report, research paper, or science fair project). The work should be in *draft* form so students can incorporate the feedback they receive into the final version. We recommend making copies of the students' work for use during this activity so their original product remains intact.

Prior to class, decide on the student pairings and modify the *copy* of the work as needed (e.g., remove names or delete/ hide sections not needing peer review). This lesson uses a one-to-one pairing (one author to one peer reviewer), but you can adapt as needed.

(**Material Preparation** is continued on the following page)

Peer Review Worksheet Options

Depending on the type of project students peer review, consider:

1. **Creating your own worksheet** that aligns with a specific assignment, using criteria from a rubric or grading checklist.
2. **Using our Peer Review worksheets** that provide a structured framework for students to give constructive scientific feedback on different types of science communication. These worksheets follow a similar structure to what some scientists use during the peer review publishing process:
    - **Summary of the Work:** reviewers briefly summarize the work to show that they read, listened to, or watched it and understand the main ideas.
    - **Major Concerns:** significant problems noted in the work, such as unclear methods, missing information, or inaccurate use of scientific concepts and processes.
    - **Minor Concerns:** small errors that are easy to fix, such as spelling, grammar, or formatting mistakes.

CLASS ONE PROCEDURES

"Would You Rather?" Activity (10 minutes)

1. Start class by briefly explaining the purpose of this lesson to students, for example: *Learning how to give and receive feedback takes practice and is a useful skill to have. Think about the different areas in your life where you give and receive feedback - at school, in a club or sport, during an internship, or even in your friendships. What makes the feedback good or bad? Since we're in science class, this lesson focuses on scientific feedback and how professional scientists may share feedback with their peers. However, I encourage you to reflect on how you can apply the activities and our discussions in other contexts - like your other classes, an extracurricular activity, a job, or in your friendships. Let's get started by first identifying what helpful and meaningful - or **constructive** - feedback looks like.*

2. Project the "Would You Rather?" Activity presentation, starting with the following scenario: *Imagine you have an important paper for a class that counts for 25% of your semester grade! Given how big this assignment is, you want to do your best. To help everyone succeed, your teacher asks you and*

*your classmates to **peer review** each other's work - that means reading each other's papers carefully and giving feedback before the final draft. The teacher emphasizes that the feedback needs to be **constructive** (in other words, helpful and meaningful) so your classmates can use your suggestions.*

3. Have students stand and form a line in the middle of the classroom for a quick round of *"Would You Rather?"* using the provided slides and the scenario above. Explain that they will step to the right or left of the imaginary center line depending on their answers. They must choose a side, even if they are unsure - but assure students there are no "right" or "wrong" answers. Before each question, have students return to the center.

"As you get feedback from your peers on your paper, would you rather..."

- Get specific, direct feedback? **OR** Get elaborate feedback with explanations?
- Get feedback on your ideas? **OR** Get feedback on your writing?
- Not know who reviewed your paper? **OR** Know who reviewed your paper?
- Get feedback on every small mistake? **OR** Get feedback on the bigger issues?
- Get suggestions for improvement? **OR** Only see the mistakes?
- Have a reviewer thoroughly read your paper and take a longer time to respond? **OR** Have a reviewer who skims your paper quickly and gives feedback immediately?
- Get feedback on your entire paper? **OR** Get feedback only on certain sections?

Depending on your students, add some fun questions to boost engagement - for example, "Would you rather get feedback in emojis or song titles?"

Activity Alternatives:
1. For more physical movement, students can move to different sides of the room.

2. For limited space or mobility adaptations, students can point, vote using a polling app, or hold up different colored pieces of construction paper.

4. After students return to their seats, show them the last slide in the presentation that lists all the options. Then, ask students the question below and record their responses on a whiteboard so they can refer to this list later (*alternative: use a virtual word cloud*).

- Reflect on the different qualities of feedback presented here or think about other characteristics. If you had to describe the kind

of feedback you prefer in 3-5 adjectives, what would they be? (*Examples: anonymous, clear, detailed, helpful, kind, positive, specific)*

5. Tell students that it's all right if their preferences differ from their classmates - people like different styles of feedback. However, in the next activity, the class will work together to identify what **constructive** (helpful and meaningful) **scientific feedback** looks like so the class can agree on shared expectations for peer review.

Scientific Feedback Examples (20 minutes)

1. Distribute the "Scientific Feedback Examples" Student Handout (found at the end of this lesson). Read the "Context" and "Instructions" together as a class.

2. Pair students to work together. For each example comment (10 total) on the student handout, have pairs decide if the feedback is **constructive** or not. For comments that are subjective or they're unsure about, ask students to suggest revisions to make the feedback more helpful and meaningful.

Class Discussion (15+ minutes)

1. As a class, review the comments one by one, pausing to discuss any disagreements. There are no right answers, but encourage the class to come to a consensus - this will help establish shared expectations for when they peer review.

2. Revisit the adjectives students listed after the "Would You Rather?" activity. Ask them which words they want to keep and if there are any they want to add. Then, have students rank the words in order of importance. Use this to compile your class's "Top 10 Qualities of Constructive Feedback." Keep these on the board for the remainder of the lesson. You can also record them on a flip chart, slide, or poster if you'd like to use them throughout the year. (*Note: students may mention some qualities that are valid but not feasible for the peer review process we*

In professional scientific communication, the "dreaded Reviewer 2" has become a metaphor for a peer reviewer who provides unhelpful and sometimes unkind feedback as described in this 2023 American Chemical Society letter. A 2021 Letter to Young Scientists in *Science* shares four tips from professors for keeping feedback "useful and respectful": be humane, embrace intellectual humility, avoid straw men (exaggerating claims to critique), and assume the best.

describe – for example, "quick" or "verbal." You may want to mention that there are exceptions.)

For a 45-minute class period, end the lesson here. If you have a 90-minute block, proceed to the next activity.

CLASS TWO & THREE PROCEDURES

Quick Recap (< 5 minutes)

If you have 45-minute class periods and are starting on a new day:

1. Cover or hide the list of "Top 10 Qualities of Constructive Feedback" from the previous day. Ask students to recall the qualities.

2. Remind students that these are shared expectations for the feedback they will give their classmates.

If you have 90-minute class periods and are continuing the lesson:

1. Remind students that these are shared expectations for the feedback they will give their classmates.

Peer Review Activity (40-85 minutes)

You may want to set time limits or checkpoints for this activity to help students stay on track. (*Note: the time required for the Peer Review Activity depends on your students' experience and the work being reviewed. Students may need additional time to incorporate the feedback they receive into their final product.)*

1. Distribute printed copies of your chosen Peer Review worksheet or refer students to your LMS to digitally access it. Briefly walk students through the worksheet, focusing on the main sections and directions given. Emphasize that students should only complete the worksheet after they have reviewed their classmate's work, but they can jot down notes on a separate sheet of paper/ document while they are reading, listening to, or watching the product.

Should peer review be anonymous to both authors and reviewers? This question is debated in professional scientific communities, with both sides providing valid arguments. Remaining anonymous may lead to more honest reviews, yet open reviews may lead to better accountability. Whether your students' reviews are anonymous or not, we recommend strategic pairing to ensure the matches are a suitable fit.

Possible modifications for the Peer Review Activity:

- Pre-highlight the text or crop the audio/ video (on the copy, not original!)
- Reduce the number of sections to review
- Share a worksheet with sentence starters

2. Assign the peer reviewers by handing students physical copies of the work (e.g., lab report) or sharing the digital copies (e.g., links to videos in a shared folder). Encourage students to *thoroughly* read, listen to, or watch the product. This ensures the peer reviewer is familiar with the material, though it's all right if they don't fully understand it.

3. After they read, listen to, or watch their peer's work, have the student peer reviewers complete the worksheet and turn it in when they finish. Before sharing the feedback with the student authors, read through the comments to moderate them – is the feedback constructive, and does it align with your assignment expectations? If you have time, you may want to write your own comments on the worksheets, either agreeing with the peer reviewer or explaining why a suggestion isn't necessary.

4. Optional: Ask students to incorporate the feedback they received into their final draft. To check if they make edits, ask them to show track changes on a document, write a brief summary of what they changed, or have their peer reviewer briefly read, watch, or listen to the work again.

EXTENSIONS

- Continue to use the Peer Review worksheet throughout a unit, semester, or year on various science-related projects. Gradually increase the rigor by prompting students with higher-level questions or cross-curricular connections - for example, credibility of references, statistical analyses and interpretations, variety of visuals (e.g., tables and charts), etc.
- Have students use the Peer Review worksheet (or a modified one) to analyze a public science communication (e.g., a scientific journal article, a preprint, a blog, a video, or even a social media post). Afterwards, lead students in a discussion to identify how different types of science communication may have varying expectations for content and style.

ASSESSMENTS

The following prompts offer different ways for students to reflect on and apply what they have learned:

- Assess peer reviewers based on the "Top 10 Qualities of Constructive Feedback." For example, how many qualities out of 10 did they meet? Provide brief suggestions for improvement. *Alternative: have students who received feedback conduct this assessment of their peer's review.*
- Ask students to reflect on their experience as an author receiving feedback and a peer reviewer giving feedback. How did the feedback they receive compare to the feedback they gave? What are 2-3 suggestions for themselves and their classmates to improve as peer reviewers?

REFERENCES

This lesson plan draws on resources and information provided by the organizations listed below:

- Emerging Investigators Preprint Server (eiRxiv) - eirxiv.org
- Journal of Emerging Investigators (JEI) - emerginginvestigators.org

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At eiRxiv and JEI, we are committed to providing the tools, mentorship, and community necessary for any middle or high school student to publish and share their research with other students and the broader scientific community. Visit us at eiRxiv.org and emerginginvestigators.org.

SCIENTIFIC FEEDBACK EXAMPLES

Context:

For her 11th grade Environmental Studies class, Annie completed a year-long independent research project exploring how wildfire severity affects water retention in soil (how much water stays). Before writing their final reports, Annie's teacher asked students to **peer review** each other's work to give feedback. The goals of this peer review were to make sure that:

1. Students accurately described the full experimental design (**scientific method**) of their research projects - that is, the science was correct and important information wasn't missing, such as variables (independent and dependent) and hypotheses.
2. The reports mostly had correct spelling and grammar.

Each student reviewed two other classmates' reports and received feedback from two different peers. All comments were anonymous.

Instructions:

With a partner, read some of the feedback Annie received (next two pages). For each comment, decide whether it is **constructive** or not *and* explain why. If it's subjective or you're unsure, suggest revisions to make it more helpful and meaningful. Consider what would help Annie improve her paper before turning it in for a final grade.

Be prepared to justify your decisions during the class discussion.

Peer Reviewers' Comments	Is it constructive?	Why or why not?	How to improve it?
1. I like your project. Wildfires can be bad and flooding often happens after them, so this is important.	☐ Yes ☐ No		
2. I wonder why you measured water retention as the *amount of water that left* after the soil was saturated. It might be helpful to explain why you collected your data like this.	☐ Yes ☐ No		
3. Your graphs are easy to view, but they don't match what you said in your paper. You should fix that.	☐ Yes ☐ No		
4. This is a really important topic because wildfires have become so intense. You mentioned flooding in your Introduction, but the connection between them and wildfires wasn't totally clear. Maybe you could explain that a bit more? This would show why you wanted to know more about water retention in soil after wildfires.	☐ Yes ☐ No		

Peer Reviewers' Comments	Is it constructive?	Why or why not?	How to improve it?
5. I noticed a few spelling errors in your report like "en**virom**ent" and "sign**ifca**nt." There were a few others, so you should run spellcheck again.	☐ Yes ☐ No		
6. Some parts of your paper were kind of confusing for me. Maybe you could explain those parts better?	☐ Yes ☐ No		
7. I noticed you only cited other people in your Introduction, but we need to have references in all sections.	☐ Yes ☐ No		
8. The conclusion should be longer, so add more text.	☐ Yes ☐ No		
9. I like how organized your methods were because it made your research easy to understand. However, since they should be written in paragraphs for our report, you should remove the numbered list.	☐ Yes ☐ No		
10. I liked this paper. The science seems good.	☐ Yes ☐ No		