Introducing the Understanding Science flowchart to middle school students

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Overview: Students begin with a simple "warm up" activity that introduces them to the process of science. The class discusses whether or not they were "doing" science. Students then read a story about the geoscientist, Walter Alvarez, and identify phrases within the story that indicate that Alvarez was doing science. Students are introduced to the Science Flowchart and are asked to plot the scientific journey of Walter Alvarez. Students find that science is seldom a linear story, but instead involves unanswered questions, surprising leaps, reinterpretation of data, and the unexpected.

Lesson concepts:

- The process of science involves testing ideas about the natural world with data from the natural world.
- Scientific understanding improves as new evidence and perspectives emerge.
- The process of science is non-linear.
- The process of science involves observation, exploration, discovery, testing, communication, and application.
- Scientists test their ideas using multiple lines of evidence.
- Test results sometimes cause scientists to revise their hypotheses.
- Scientists are creative and curious.
- Scientists work together and share their ideas.

Grade span: 6–8

Materials:

- ***Asteroids and dinosaurs: Unexpected twists and an unfinished story*** (www.understandingscience.org/lessons/pdfs/alvarez_ms.pdf), a story about Walter Alvarez — one copy per student
- Copies of **simple Science Flowchart** (www.understandingscience.org/lessons/pdfs/simple_flow_handout.pdf) — one per student
- Copies of **complex Science Flowchart** (www.understandingscience.org/lessons/pdfs/complex_flow_handout.pdf) — one per student *and* another for each group of four
- Highlighters — one per student

Time: One class period

Grouping: Jigsaw in groups of four and whole class

Teaching tips: Prior to this activity, students should be introduced to the nature and process of science by participating in an activity such as **Mystery tubes** (www.understandingscience.org/lessons/pdfs/mystery_tubes.html) or **Mystery boxes** (http://www.indiana.edu/~ensiweb/lessons/mys.box.html). Following these activities, ask students if they were doing science. Allow some discussion before beginning this lesson.

Using a jigsaw strategy works well for this activity. There are three stages to the process.

1) *Home/base group*: Group members are assigned to a different expert group and are given their instructions for what they will do once they are in their expert groups.
2) *Expert group*: Group members here develop expertise in one aspect of the jigsaw theme (in this case, a portion of the Alvarez article). Their role is to understand the portion they have read and come to a consensus on their task. The teacher as facilitator must check in with each group to ensure that they have reached consensus about their findings and that group members' message is the same, since they will next be sharing the information first with their home/base group and then with the class as a whole.
3) *Home/base group*: Finally, each person will return to their home group and each home/base group member will take a turn to share their expert group information.

Procedures:

1) Teacher puts students in groups of four in order to engage in a jigsaw. This group will represent the home/base

group. If students are unfamiliar with jigsaw, the groupings listed above should be explained or reviewed

2) In the home/base group each student is assigned a number which assigns the student to an area of expertise. Students will be instructed that soon they will move to their expert group where they will read a portion of a story about a geologist named Walter Alvarez. Their goal is to answer the questions: *Was he doing science? How do you know?*
   - Expert #1 will read paragraphs 1–4
   - Expert #2 will read paragraphs 5–7
   - Expert #3 will read paragraphs 8–10
   - Expert #4 will read paragraphs 11–12
3) Students are given a copy of the Alvarez story with paragraphs numbered and then move to their expert groups. While in their expert groups, students will read their portion silently to themselves. When everyone is finished, the group will discuss the two questions: *Was he doing science? How do you know?* Students will be asked to *come to a consensus* on which words (verbs) and/or phrases in the paragraphs that they read indicate that Alvarez was doing science.
4) Expert group members will then highlight the relevant words or phrases and the teacher will check in with each expert group to ensure that all group members have *the same information highlighted*.
5) "Experts" will return to their home/base group and a representative from each group will take turns reporting out what they highlighted, beginning with Expert #1. As each "expert" reports, the whole group will highlight the same words/phrases.
6) The teacher will then instruct students to number their highlights from 1–? (Each group may come up with a different number of highlights).
7) Each student will be given a copy of the **simple Science Flowchart**. Here the teacher will need to say a few words about the chart: "I have just given you what is referred to as a flowchart that is one way of representing the scientific process. Notice that there are four circles that represent *Exploration and Discovery*, *Testing Ideas*, *Benefits and Outcomes*, and *Community Analysis and Feedback.*" Here the teacher may want to make sure that students understand the meaning of these terms. Then, "Notice that they are connected by a number of arrows. For now, I just want you to think about why the arrows are placed the way they are."
8) In order to tie the flowchart to the story that they have just read, the teacher will ask for something that Walter Alvarez did that would be an example of Exploration and Discovery. What did he do that would be an example of Testing Ideas? Of Community Analysis and Feedback? Of Benefits and Outcomes? Then "So there are lots of other things that you highlighted. To help you decide which circle they match, we can actually provide a more detailed look at this flowchart."
9) Each group of students will be given a copy of the **complex Science Flowchart** and the teacher should go through all of the terms in each of the circles.
10) An additional copy of the complex Science Flowchart will be given to each group. Students will be asked to *each* take some time to place the numbers that represent their highlighted phrases on the group chart in the appropriate circle. The words will not always be a direct match, so students will have to make a decision as to the circle that is the best match. Not all students will place the numbers in the same place.
11) After all of the numbers have been added to the flowchart, students will be asked to draw a line connecting their numbers in order, like dot-to-dot. *NOTE: It is not necessary that the numbering matches for each student; Jorge may put his number 3 phrase in the "Testing Ideas" circle and Marcia may put the same phrase in "Exploration and Discovery." The idea here is to stimulate discussion among group members—they should be prompted to ask each other why they chose the circle they chose for each phrase, particularly when there is disagreement among group members.*
12) Each home/base group will now be asked to hang their group flowchart on the wall and they will then begin a Gallery Walk. The purpose of the Gallery Walk is for students to review the work of their classmates. Each home/base group, after reviewing all flowcharts, will be asked to pick another group's flowchart, which will likely differ from theirs and to pick out three similarities and differences they found and note them down.

Class discussion:

13) Students will then return to their seats and the teacher will facilitate a discussion about what they discovered in their comparison of flowcharts. Sufficient time should be set aside for this discussion. It may be necessary to com-

plete the discussion the next day.

Teacher as facilitator questions:

1) What similarities and differences did your group find?
2) How did ____ group flowchart differ in its pathway from your group flowchart?
3) Give me an example of where the majority of your group placed number ____ in (name the circle) and another group mostly placed that number in a different circle. What was your reasoning? Why do you think their reasoning may have been different? (Other group—tell us your actual reasoning.)

14) The teacher would then discuss with students what this means about science—that it is not a clear-cut process that goes from A to B to C in a linear way—that it is often very circuitous and repetitive and complicated, and that the path it takes can be interpreted differently by different "observers". It would then be pointed out that throughout the year, students will be looking at phenomena using these processes and that they will be hopping from circle to circle as they go!

15) Finally—teachers may want to revisit the **Mystery tubes** or **Mystery boxes** activity, and to determine what their pathway through the flowchart would look like and compare that to the pathway of Walter Alvarez.

Extension: Have students apply the Science Flowchart to other investigations that they conduct during the school year or to other scientists that they read about. Charting the pathways of each of these will reinforce the nonlinear, creative, and dynamic nature of science.