**1. Thick and Thin Questions**

Thick and Thin Questions is a strategy for deepening students’ reading comprehension. Students are asked to create questions of varying depth about a text. Thin questions serve to clarify specific details or words in the text, and usually begin with *who, what,* or *where.* Thick questions lead to deeper discussions that go beyond the text itself and explore important concepts, themes, and possibilities. Students may also need to do additional research or reading to answer the question. Thick questions tend to be more open ended and complex, and may begin with *how*, *why*, *I wonder*, or *what if.*

There are many ways to structure activities using thick and thin questions. One option is to ask students to write their questions on separate post-its while they’re reading a text, and then have the class discuss each question and explain why it’s a thick or thin question. The questions can be sorted and posted on a two-column chart in the classroom. Another option is to have students write questions of both types on a two-column chart. Students then begin a discussion by taking turns reading their questions to the class, starting with thin questions first.

Texts in science classes might include narratives about a scientific discovery, scientific papers or reports, data sets, peers’ lab journals, science trade books written for children or a general audience, newspaper or magazine articles, etc. Exploring different types of questions about these texts can help students learn to recognize, write and refine the types of questions that can be answered through scientific investigation (by gathering evidence to support an explanation); or in engineering, questions that help define a problem to solve and the criteria for a successful solution.

*Adapted from* McLaughlin & Allen (2000)

**2.Transitioning from Everyday Language to Academic Lanuage (Bridging Registers)**

In bridging between registers, students are asked to translate back and forth between formal and informal, or colloquial and technical language. For example in science, students might be asked to explain their own commonsense views on a topic in more colloquial language, and then to rephrase their statement using a more technical and formal scientific style. Or, students might translate a concept described in technical, scientific language into a less formal register.

Ideally, students would have regular opportunities to translate ideas between registers and practice doing so in both writing and speaking. Bridging between registers allows students to practice more formal scientific language while honoring the important role their everyday language plays in building their knowledge of science. In addition, the activity presents opportunities to discuss when to use one register or the other to accomplish a specific communicative purpose.

Teachers can model this practice by frequently translating their own statements and making explicit to students when they are using the different registers. To build students’ metalinguistic awareness of the different registers and when to use them, some teachers keep anchor charts about “Talking like a scientist” that include examples of more formal or technical phrasings and questions. Another option is to pause during instruction and ask students to translate back and forth, or to have students work together translating, for example, an explanation written in their own words in their lab journal into more technical or formal language.

*Adapted from* Lemke (1990) and Fang (2010)

**3. Science Literature Circle**

In a science literature circle, students explore science content through literature including magazine articles, picture books, biographies of scientists, poetry, etc. As they read and discuss the literature, students assume different roles on a rotating basis. Commonly used roles for literature circles such as *questioner, summarizer,* and *illustrator* are more general and apply to any text, but Straits & Nichols (2006) and Fang (2010) describe several literature circle roles that focus on deepening students’ science learning:

* **Science Translator:** to identify new science words, look up a definition of the word, and share findings with the group
* **Science Biographer:** to use library and web resources to find more information about the scientists or other significant individuals discussed in the text
* **Everyday Life Connector:** to find connections between the text and current, everyday life in students’ local community or elsewhere in the world
* **Science Skeptic:** to critically analyze the claims, conclusions, evidence, research methods, and other aspects of how science is done as described in a text
* **Historian:** to describe other scientific breakthroughs happening at the same time as a scientific discovery detailed in a text, or to provide some historical context for more recent discoveries
* **Science Sleuth:** to find additional information about science concepts, ideas, and methods described in a text

Literature circles can be a great way to build on students’ interests and motivation. Students are often given a choice in the text they read, and do not necessarily read the same text as their peers in the literature circle. Also, the focus in literature circles is usually on the questions students bring, rather than questions that are pre-determined by the teacher.

*Adapted from* Straits & Nichols (2006) and Fang (2010)

**4. Claim Cards**

Claim cards give students practice evaluating claims, identifying misconceptions, constructing scientific explanations, and engaging in scientific argumentation. They consist of a set of claims written on separate cards about a phenomenon, object, or event. Students evaluate each claim by considering the evidence that supports or refutes it, and then they select the one best supported by evidence.

Start with a question that can generate a variety of claims, such as *“What is causing the collapse of honey bee colonies?”* Then, write different claims students or other people make about the phenomenon. Different claims about honey bee colony collapse could include: pathogen (virus or bacteria), parasite (Varroa mite), environmental stressor (pesticides, lack of nectar and pollen diversity), or colony management (beekeeping practices). Divide students into small groups according to the number of cards and have the groups distribute one card to each person. Each person reads the claim on their card and describes the evidence that supports or refutes it. Other group members then have a chance to add evidence, or to refute the claim being made by pointing out reasons why the evidence does not support it. After all claims have been discussed, groups choose the best supported claim and explain their reasoning to the class.

*Adapted from* Keeley (2015)

**5. Learning Logs**

Learning logs are a type of writing journal that promotes metacognition and helps deepen students’ emerging understanding of science concepts during inquiry-based investigations. Learning logs also provide students opportunities to continually reflect on their learning as it progresses during a unit of instruction, and also to receive feedback on their learning from teachers and possibly peers.

To help students begin writing, consider having a class discussion about what students have been studying or working on, and capture notes on a chart that students can refer to as they start writing. Also, having a set of writing prompts or sentence stems can help students choose what to write about and how to begin.

|  |  |
| --- | --- |
| I was successful in…I feel good about…I figured out…I observed/ noticed that…I really understood…I got stuck/ confused when… so I…I’m not sure…The most challenging part of this was…I previously thought \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, but now I think \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.I didn’t expect…It surprised me when…I think I need to redo…I need to rethink…I’m trying to understand…I will understand this better if I…I think tomorrow I would like to try…I wonder… | In the [lab or lesson], I thought \_\_\_\_\_\_\_\_\_\_ was interesting because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.What we did today reminds me of…I would like to further explore \_\_\_\_\_\_\_\_\_\_\_ because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.What I’m learning in science is related to something we talked about in\_\_ [another class/ extracurricular activity/ home or community activity]\_\_\_... *(Give details)* I would like to learn more about \_\_\_\_\_\_\_[phenomenon/topic]\_\_\_ by \_\_*(doing what?)*\_\_\_\_\_\_. |

Learning logs can be a planned regular activity or an impromptu strategy for encouraging students to monitor their own learning and, if the logs are collected, to provide students feedback and gather data to inform instruction.

It is important to build shared understanding of the purpose of the learning log at the beginning of the year. In addition, it is helpful to have samples of learning logs from previous years to give students an idea of what to write, how informally or formally to write, the types of drawings or other visuals students are encouraged to include, and other expectations for the learning logs.

*Adapted from* Wheeler-Toppen (2011) and Keeley (2008)

**6. Refutational Texts**

A refutational text is a type of persuasive writing that can deepen students’ understanding of a scientific concept by refuting a misconception related to the concept. A refutational text introduces a misconception; refutes it; presents an alternative concept, idea, or theory; and then supports the new concept, idea, theory, or claim with evidence. Refutational texts present two sides of an argument, but state very explicitly which argument is more valid and why.

Prompts for refutational writing should relate to core scientific ideas and concepts about which there are often misconceptions, such as “what causes the seasons?” or “what causes a cold?” Often, students need to do further research into the topic or gather their own evidence through observations or experiments in order to recognize misconceptions and refute them with evidence.

Example from Fingon & Fingon(2011), *“Using Science Journals to Encourage All Students To Write”*

in Wheeler-Toppen (2011), p.50:

Many people believe that a change in the Earth’s distance from the Sun causes the seasons to change. *However, this cannot be true, because the seasons are different in the Northern and Southern Hemispheres.* The actual cause of the seasons is the way the Earth is tilted on its rotational axis. When the Earth’s axis points toward the Sun, it is summer for that hemisphere. When the Earth’s axis points away, it is winter for that hemisphere. This is because the hemisphere that points toward the Sun receives more direct sunlight and has longer days.

*Adapted from* Wheeler-Toppen (2011) and Fang (2010)

**7. Discussion Moves for Science**

Discussion moves for science (see chart on the following page) make explicit the ways students can contribute to and participate in conversations to deepen their learning about science investigations and concepts. Learning through discussion in science can serve multiple purposes for students: connecting new ideas to prior knowledge and experience; learning to attend to others’ ideas while solving problems or designing experiments collaboratively; clarifying understanding of concepts and processes in scientific inquiry; and constructing scientific explanations with claims, evidence, and reasoning. Teachers and students can use discussion moves to guide and scaffold the academic discourse associated with these activities.

In order to create a climate in which students feel comfortable learning science through talk, it is helpful to involve students in establishing group norms for discussions and co-creating question and response stems specific to the science and engineering practices. As students are learning to use the discussion moves, teachers can make the discussion moves visible for students’ reference (by creating a classroom chart or sets of cards with the discussion moves) and encourage students to focus on one or two for a given discussion.

*Adapted from* Zwiers (2008), Zwiers & Crawford (2011), and Michaels & O’Connor (2012)

**Discussion Moves for Science**

|  |  |
| --- | --- |
| **Repeat, rephrase, or summarize ideas*** Who can restate \_\_\_\_\_\_\_\_\_\_ in their own words?
* So far, we have talked about…
* So what you’re saying is…
* Based on the data we have, can we make any claims about…?
* How can we summarize our data? What patterns do you see?

**Clarify ideas** * What do you mean by…?
* I think it’s more helpful to focus on…
* What is Laura trying to say?
* The most important point here is that…
* This is/ isn’t relevant because…

**Compare thinking and reasoning*** Do you agree or disagree with Tenzin’s explanation?
* Which idea seems strongest to you and why?
* I think what I’m saying is similar to what Luis said…
* I disagree with Abdi’s claim because…
* We decided to organize our data differently because…
* I notice some difference/ similarities in …
* How does \_\_\_\_\_ compare to \_\_\_\_\_?
* What are the strong/ weak points in this explanation?

**Provide or request wait time and thinking time*** Let’s spend a few minutes writing down our initial ideas before sharing them.
* …[silence]…
* I need to think about that a little more. Can you come back to me later?
 | **Elaborate and explain ideas*** Can you say more about why you decided to…?
* Can you tell us how you figured out…?
* Why do you think…?
* Did you consider…in your experimental design?
* Why did you think it was necessary to \_\_\_\_\_\_\_\_\_ in your experiment?
* What are some of the limitations of our [data/ model] for explaining…?
* What is your evidence?
* Can you give an example/ counterexample?
* What could be the reason for…?

**Add an idea or explanation or build on another’s*** I would like to build on Sara’s idea…
* I want to add…
* This relates to what Marco said…
* What else can we add to that idea?
* Another possible explanation is…
* Another way to represent our data is to…
* I also observed that…

**Make connections*** This reminds me of when …
* I think this relates to something we talked about in [another class]…
* Have you ever seen or experienced \_\_\_\_\_\_\_\_ firsthand?
* What do you already know about…?
* What have we learned from our previous investigations this year that could help us understand…?
* What can we learn from this investigation?
* How is this important or useful to us?
 |

**8. Writing Scaffolds for Lab Journals**

Writing scaffolds for lab journals (see chart on the following page) help students think and write in a scientific way during inquiry-based investigations. This includes making sense of their observations and data, learning to build and communicate a scientific argument or explanation, and reflecting on their learning over time. The guiding questions and response frames listed in the chart address the multiple processes involved in doing a scientific investigation. They can help students keep track of important information during experiments and prepare to share their findings after completing their investigation.

As the investigation progresses, give students opportunities to talk about and share their journals with their peers and teacher(s). Also, encourage students work collaboratively with their lab groups to record the following in their lab journals: the details (including drawings) of their experimental design and reasons for designing it that way, different ways to represent or summarize data, questions that emerge during the study among lab group members, and other information that is relevant to the investigation.

Once the investigation is complete, lab journals can be a helpful tool for building metalinguistic awareness as students discuss how to communicate their findings in different ways. For a formal lab report, teachers can model when it’s appropriate to change present tense verbs in the lab journal into past tense for the lab report and when to use more condensed language or active/passive voice. Students and teachers can also talk about language choices that would be most effective if students are going to present their findings in other ways, such as a multimedia presentation for a general audience, an illustrated story book for a younger audience, a class publication, a talk show in which they are the guest scientists being interviewed, a symposium (several students presenting their findings related to a certain topic in the format of an academic conference), or an email announcing their recent findings to a colleague.

*Adapted from* Fang (2010), Grant & Fisher (2010),

**Writing Scaffolds for Lab Journals**

|  |  |
| --- | --- |
| **Guiding questions and prompts** | **Response frames** |
| **Introduction, Question/Problem**What question or problem are we investigating? Why is it important?What do I already know about what I’m studying?What have other scientists already investigated related to our study?How will the study advance our knowledge?Why did I choose this type of experimental design – how does it help me answer the questions? | We are investigating… We are investigating possible mechanisms to explain…We are investigating possible effects of…on…The purpose of this investigation is to…We chose this experimental design because…Another reason is that…I want to find out…We already know that…Question: |
| **Procedure, Methods**How did I solve the problem? (List the steps)What materials/ tools/ organisms are we using in our study?How will I collect data?How will I analyze data?Describe the materials, organisms studied, study site (for field studies), experimental design, and procedures for collecting, summarizing, and analyzing data.  | First,… Next,…[Draw a picture of the experimental set-up]We are using \_\_\_\_\_\_\_ to measure \_\_\_\_\_\_\_\_\_.We are observing changes in…We will measure\_\_\_\_\_\_\_ every [5 minutes/ two hours/ week] for a total of… |
| **Results**What did I find out?How can we summarize the data?What differences/similarities, trends in the data, anomalies, correlations, maximums, minimums, etc. did we notice?Use text, tables, figures to present key results without interpretation | In x% of experimental groups…We noticed key differences in…We observed similar \_\_\_\_\_ in…No differences were observed after [length of time].The maximum \_\_\_\_ was in group \_\_\_\_\_\_\_\_. The minimum \_\_\_\_\_\_\_\_\_ was in group \_\_\_\_\_\_\_\_.As the \_\_\_\_\_\_\_ increases, the \_\_\_\_\_\_\_\_ decreases.There is a correlation between \_\_\_\_\_\_ and \_\_\_\_\_\_\_. |
| **Discussion, Explanation/ Interpretation**What did we learn?What does it mean?How do we interpret our findings?What new understandings do we have of the problem we investigated?What other questions might we investigate next? | The data show that…We discovered that…Based on our data, we can conclude…The results seem to indicate that…Our data provides evidence for…Based on our data, it is likely that… |

**Resources**

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