Session 7: Classroom Conversations

Contents

Session Overview

This session introduces participants to more pedagogical information and experiences highlighting the importance of classroom discussions, while also modeling strategies that participants can use with their own students.

Participants explore the role of dialogue in learning by: reading and sharing short excerpts from research; observing a video of a classroom lesson and analyzing coded transcripts; and taking part in a dry ice investigation and discussion. They examine common patterns of teacher student exchanges during discussion, the benefits of teacher guidance in learning science, and the importance of peer-to-peer discourse.

During the dry ice investigations, individual participants have the opportunity to take on the role of teacher, and to practice asking questions that encourage observations, investigations, and explanations. At the end of the session, they review all the strategies used in the session that they can also use in classrooms with children.

Background Information for the Presenter

From our own experiences in learning and teaching situations, we can all recognize the important role that conversation, discussion—TALK—plays in any socially connected group of learners. It is through such ***discourse*** that the meaning-making needed for the development of ideas and concepts can be accomplished. From the sociocultural viewpoint, learning occurs through discourse within social interactions (Rogoff, 1998; Vygotsky, 1978). Vygotsky emphasized the importance of discourse by arguing that higher mental functions have social origins that are first expressed between individuals *before* they are internalized within the individual—that learning relies on discourse. For students, engaging in discussions and conversations can foster more creative, complex thinking and enable them to practice crucial abilities, such as asking questions and communicating ideas effectively. For teachers, all manner of talk and discussion in the classroom provides a window into students' prior knowledge, skill-level, personality, previous experience, and ability to articulate ideas and reasoning. Such discourse happens in many ways.

Reflective Discourse.
When a teacher facilitates a conversation where students, as well as the teacher, pose questions, respond to one another's comments and questions, and seek to understand each other, this exchange can be referred to as reflective discourse. The student has the freedom to express his or her own thoughts, ideas, and questions while authentically engaged and curious about the subject of the discussion. The teacher and students can thus engage in a free-flowing exchange, asking and answering one another's questions, and trying to understand the thinking of the other person (van Zee & Minstrell, 1997).

Dialogic Instruction
In a dialogically organized classroom, the teacher uses reflective discourse to validate and elaborate upon student ideas and guides them to "negotiate" their understanding with the other students in the class. The teacher uses strategies such as uptake (Collins 1982) where a particular student's response is incorporated into a question to the group, in order to encourage students to build on others' ideas. The emphasis is on creating a "give and take" where student responses help shape the course of the discussion, as opposed to relying on the teacher asking questions to drive the exchange. A dialogic approach to instruction is often characterized by the use of broad questions, which do not have pre-specified answers and therefore convey a genuine interest in students' opinions and thoughts. The discourse in these classrooms is therefore less predictable and repeatable because it is jointly determined – in character, scope, and direction –by both teachers and students as teachers pick up on, elaborate and question what students say (Nystrand, 1990a, 1991a). Dialogic conversations engage students because they validate the importance of students' contribution to learning and instruction. The purpose of dialogic instruction is not so much the transmission of information through the teacher, as the interpretation and collaborative co-construction of understandings by the students themselves (Gamoran & Nystrand, 1992).

Monologic Instruction.
In what has been called monologic instruction, also termed a "teacher monologue," the teacher explains, describes, clarifies, identifies, and questions. In this type of instruction the main goal is for the teacher to present scientific views and explanations. The teacher is doing most of the talking, although whose turn it is to talk may alternate between

teacher and students. Monologic instruction can be criticized for reducing opportunities for students to derive and articulate their own understanding of scientific ideas. It can also be criticized for expressing the viewpoint that scientific knowledge is obtained primarily from the teacher (or another expert source), and for not giving students the opportunity to learn science by thinking scientifically, and exchanging and evaluating ideas against evidence as scientists do. Monologic instruction may be a fine method to achieve learning that consists of memorizing facts and information, but it can hinder a deeper more conceptually focused type of learning for students.

I-R-E and I-R-F
Of course, there are variations in teacher directed talk. In one pattern, abbreviated as I-R-E, the teacher initiates the conversation with a question or comment (I), the student responds (R), the teacher evaluates the response (E), and then repeats the pattern with another question (Lemke, 1990; Mehan, 1979).

IRE example:
Teacher: Is this a solid, liquid or gas? (Initiate)
Student: It's a liquid. (Respond)
Teacher: Yes, it is a liquid. It takes the shape of its' container. (Evaluate)
Teacher: What about this one, is it a solid, liquid or gas? (Initiate)
Student: It's a liquid too. (Respond)
Teacher: No, this one is a solid. (Evaluate)

The student responses may be short answers, while the teacher's evaluations of the responses may be long and elaborate. In another variation, often called I-R-F the teacher initiates the conversation with a question or comment, the student responds, the teacher seeks follow-up ideas and comments from the students, then the pattern repeats with response and follow up (Sinclair & Coulthard, 1975).

IRF example:
Teacher: Is this a solid, liquid or gas? (Initiate)
Student: It's a solid (Respond)
Teacher: What makes you say that it's a solid? (Follow-up)
Student: Because it holds its shape. (Respond)
Teacher: You're right, it is a solid. (Evaluate)

In both cases, the turn-taking switches back and forth between teacher and student regularly, and the teacher directs the conversation and makes knowledge public. Again, these patterns often fail to provide students with opportunities to articulate their own understanding and express themselves in the language of the discipline (Alexander, 2005 ; Wellington & Osborne, 2001). On the other hand, such interactions can be a way to extend the student's answer, to draw on its significance, or to make connections with other parts of the student's total learning experience (Wells, 1999)

Peer-to-Peer Discourse
Peer talk occurs in pairs or groups of students where adults are either not present or are refraining from full participation in the discussion. Researchers believe that having a more equal structure for participation in a discussion (i.e. when the teacher acquiesces control to the students) promotes more active cognitive involvement, as students may

not be as intimidated from freely expressing their ideas. (Rogoff 1990, Piaget 1977) Recent studies on discourse patterns have found that talk with other children can help provide the opportunity for the kinds of social interactions that help support student learning (Blum-Kulka & Snow, 2004).

These various patterns of talk are neither intrinsically good nor bad; their merits and demerits come from the reason and ways they are used to support and achieve intended goals. In teaching science, there is often tension between the teacher imparting information and directing the conversation to communicate the views of science and "holding themselves back" in the conversation in order to encourage children to develop their own ideas, and for everyone to voice their views.

A single science lesson may incorporate a variety of different dialogue approaches based upon the needs at each stage of the lesson. For instance, a teacher may begin with reflective discourse in order to give students a chance to express their everyday views in order to motivate and encourage students to be engaged, to legitimize students' ways of thinking, and to probe students' prior knowledge. The teacher may then shift to IRF to draw out more of students' thinking and guide the expressions of their understanding towards the scientific views. The teacher may transition into an IRE pattern in order to model how to connect students' everyday ideas to scientific language, and then finish with more open-ended reflective discourse to give students the opportunity to practice using this academic language.

Teachers' Role in Science Discussions

Learning science adds increased complexity to the practice of facilitating discourse, because it involves acquiring the language and tools of science and the accepted methods of reasoning in science (Anderson, Holland, & Palincsar, 1997; Kuhn, 1962) This process of acculturation is not possible without guidance and assistance from a more expert mentor (Scott, et al., 2006).

> "Learning science, therefore, is seen to involve more than the individual making sense of his or her personal experiences but also being initiated into the 'ways of seeing' which have been established and found to be fruitful by the scientific community. Such 'ways of seeing' cannot be 'discovered' by the student—and if a student happens upon the consensual viewpoint of the scientific community he or she would be unaware of the status of the idea" (Driver, 1989, p. 482).

Thus it is necessary for science teachers to engage students in dialogue about their everyday views of phenomena, **and** to introduce the perspective and conceptual understandings adopted by the scientific community (Scott, et al., 2006).

It is important that students have the opportunity both to make explicit their everyday ideas and to apply and explore newly learned scientific ideas through talk and other actions for themselves (Scott, et al., 2006). The fundamental point here is that "meaningful learning involves making connections between ways of thinking and talking…between everyday and scientific views" (Scott, et al., 2006, p. 622). This type of discussion offers the student the opportunity to voice her or his everyday views of the world in common language, but requires the assistance and guidance from more knowledgeable individuals to make connections between everyday views and scientific views (Scott, et al., 2006). Analyzing the patterns of talk and insights from student conversations provides participants with information about the benefits of talking with students and allowing them to articulate their own thinking.

Research clearly shows that giving students an opportunity to discuss their ideas in the context of analyzing the arguments of others significantly helps with the development of scientific knowledge (Osborne, Erduran, & Simon, 2004). So why do so many teachers rely mainly on monologic instruction and I-R-E if there is substantial and widespread research supporting the idea of creating classroom situations in which students actively discuss ideas,? It may be due to the following concerns and questions teachers often raise:

- How to ensure enough time for students to fully explore topics, in addition to covering the concepts required by state and district standards
- Concern that students bringing up inaccurate ideas in discussion it may be a distraction or an impediment to learning the correct scientific information (i.e., reinforcing misconceptions)
- How to keep students on-task and focused on discussing the assigned topic
- What to do if the students bring up questions that the teacher cannot answer or topics that are unfamiliar
- Being reluctant to "lose control" of the classroom discussion if it is not teacher directed.

It can be challenging for teachers to create situations in the classroom in which students consider and talk about their everyday views, connect those views with scientific explanations, and, in the process, encourage concept and skill development as dictated by standards and other state or district learning goals. By modeling dialogic reflective discourse strategies in this and other sessions, we hope to engage participants in seeing both the incredible value of discourse for their own learning, and also how scientific discourse can successfully be put into practice in the classroom.

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Materials and Preparation

Materials Needed

For the Session:

- LCD projector and screen, or overhead projector.
- PowerPoint slides or overhead transparencies
- **Windows on the Classroom Series: Growing Science Inquiry, DVD from** National Gardening Association, 1998

For the Jigsaw Activity:
For each team of four:

- 1 set of the following research cards:
  - #1 Zone of Proximal Development (ZPD) - Vygotsky
  - #2 IRE (Initiate, Respond, Evaluate)
  - #3 Dialogic Classrooms - Nystrand
  - #4 The Role of Dialogue in Learning
  - #5 Peer-to-Peer Discourse
  - #6 Value of Guidance in Learning Science
  - #7 Science as a Sociocultural Process - Lemke

For Watching and Coding Potato Video:

- 1 copy of the Potato video
- DVD and projector for Potato video
- 1 copy of the *Coding Teacher Moves* sheet for each participant

For the Dry Ice Investigations Exemplar:
For the class:

- 1 electric water heater/hot water dispenser (coffee pot)
- 1 cold water dispenser (use a dish tub, pitcher, unplugged hot water dispenser or water cooler, if you have no running water in your classroom)
- 1 plastic dish tub
- 1 box of ziplock sandwich bags
- 1 8-10 lb. slab (or pellets) of dry ice
- 1 hammer to break up dry ice
- 2 dish cloths or towels
- 1 insulated container to store dry ice

For each team of 4–6 participants:

- 4-6 plastic spoons
- 1 tray or small tub
- 5 clear plastic cups
- 2 metal tweezers
- 2 balloons
- 2 cups that will not melt with hot water in them (such as heavy plastic or Styrofoam)
- 2 droppers
- 2 small plastic flasks or vials **(*without*** lids)
- 1 or 2 pennies, or other metal objects
- 1 copy of the *Dry Ice Challenges* sheet

> ***Warning:*** *If dry ice is placed in an airtight container, pressure from the gas released from the dry ice may burst the container. If the container is glass, this can be particularly dangerous.*

For the Conclusion and Quick Write:
- 1 copy of the handout, *Classroom Discussion Activities* for each participant
- 1 sheet of blank paper for each participant

Preparation of Materials

1. Set up the PowerPoints, computer, LCD projector and screen, or overhead projector and transparencies.

2. Set up DVD player with Potato video

3. Prepare the Jigsaw Research Cards
   Groups will need one copy of each:
   #1 Zone of Proximal Development (ZPD) - Vygotsky
   #2 IRE (Initiate, Respond, Evaluate)
   #3 Dialogic Classrooms - Nystrand
   #4 The Value of Dialogue
   #5 Peer-to-Peer Discourse
   #6 Value of Guidance in Learning Science

   - Make copies of the cards, cut up the cards, put one of each card in an envelope, or paper clip them together to make a set for each group of six participants.

4. Prepare the Dry Ice Challenges Cards
   - Copy *Dry Ice Challenges* sheets. For each team copy one sheet of *Dry Ice Challenges*.

5. Make copies of take-home handouts:
   For each participant:
   Make one copy of the following handouts:
   - Coding Teacher Moves
   - Classroom Discussion Activities

For the Dry Ice Investigations Exemplar

Before the Day of the Activity

1. Obtain the materials for the session.

Dry ice: Obtain one 12" square slab of dry ice. These usually come about two inches thick. Dry ice can also be ordered in 1/2" diameter pellets, but these will dissipate (or "sublimate") more quickly than a slab. Wrap the dry ice with towels, blankets, rags or newspaper, and pack it in a well-insulated container. The more you insulate it, the longer it will keep. **Do not store dry ice in a freezer or refrigerator** (they are not cold enough to preserve dry ice).

> *Note:* If you are unable to obtain dry ice, you may substitute an investigation of some other interesting materials or organisms you have access to. What is important is that it be an activity they can implement in their teaching situations, and that it provide excellent opportunities for peer-to-peer discussion, as well as an excellent opportunity for a teacher-led discussion about their discoveries.

2. Prepare for Dry Ice discussion. Read through the Dry Ice discussion suggestions for ideas about how to encourage open-ended discourse.

The Day of the Activity

For the Dry Ice Activity:

1. Set aside *Dry Ice Challenges* sheets. Set near your presentation area the *Dry Ice Challenges* sheets you prepared.

2. Set up Dry Ice materials. Prepare one tray for each table of 4 or 6 students containing:

2 plastic cups, 2 metal tweezers, 2 balloons, 2 cups that can hold hot water, 2 medicine droppers, 1 spoon for each student, 2 small plastic flasks/vials (***without*** lids), 2 pennies or metal washers.

Note: When dry ice is placed in a container sealed with a lid, the container may "explode." (see also Note on page 7.)

3. Set out *Dry Ice Challenges* sheets. In a central location, place the following materials:
• 1 *Dry Ice Challenges* sheet for each team.

Just before class:

1. Fill and plug in the electric water heater.

2. Break dry ice into tiny pieces. Lay a slab of dry ice on a towel, T-shirt, or other rag. Place another towel or dishcloth on top of it. Use the side of a hammer to pulverize the dry ice through the rag. Break the dry ice into powder and tiny pieces, and put them in a small, insulated container.

Instructor's Guide

Session Objectives

• Read short excerpts of writing and research to become aware of such ideas as the zone of proximal development, I-R-E (Initiate, Respond, Evaluate), characteristics of dialogic classrooms, value of dialogue in learning, and the value of guidance in learning science.
• Code transcripts of a teacher leading a science discussion, watch video footage of it, and become more aware of patterns of classroom discourse, and their effects.
• Experience a variety of strategies (Partner Share, Jigsaw, Think-Pair-Share) that can be used to encourage discourse in their own teaching situations.
• Become aware of *Dry Ice Investigations* GEMS (Great Explorations in Math and Science) guide exemplar activities.
• Practice using questions to encourage observations, investigations, and explanations.
• Take part in a discussion of their discoveries with dry ice led by the instructor, while witnessing discussion-leading strategies modeled by the instructor.

Session Activities at a Glance

Partner Share: Why Is Talking Important for Learning?
The session begins with participants discussing in pairs the following questions:

- Why is talking important for learning?
- What strategies might be used in a classroom to encourage discussion between students?

This serves as an invitation, stimulating interest in the topic, encouraging participants to think about and access their prior knowledge and experience of the topic. It also serves as a model of the Partner Share activity, which they can use with their own students to encourage student-to-student discussion in their classrooms.

Jigsaw: Research Cards on Talking and Learning
In groups of four, each person is responsible for quickly reading and taking turns presenting to their group the information from one research card on the topic of classroom discourse. They include their own reactions to the information and questions they have about it, leading a discussion on the topic within their group.

Watching a Discussion Video and Coding Transcripts
Participants watch a short video in which a teacher is leading a discussion about a classroom investigation about potatoes. They receive transcripts of the discussion and classify the teacher "moves" in the transcript, based on codes for specific types of teacher responses. They conduct a Think-Pair-Share activity, discussing what the teacher did or did not do to encourage discussion, and how the students reacted.

Dry Ice Investigations Exemplar
The instructor leads the participants through an activity in which they design and conduct their own investigations with dry ice. During this portion of the activity, one member of each small group plays the role of "teacher," asking questions to encourage observations, investigations, and explanations from their fellow group-members. After their investigations, the instructor leads a large group discussion about their explanations for some of the interesting things they noticed. This serves as an example of model-teaching on the part of the instructor, using the discussion map strategy to model how to lead a discussion.

Conclusion and Quick Write
The leader explains that the Partner Share, Jigsaw, and Think-Pair-Share activities they took part in can also be used to encourage discussion with children in classrooms. Participants receive a handout describing these and a few other activities. Participants do a Quick Write on how to promote discussion in their own teaching situations.

Time Frame

Partner Share: Why is Talking Important for Learning? (5 minutes)
Jigsaw: Research Cards on Talking and Learning (30 minutes)
Watching and Discussing the Potato Video and transcript (35 minutes)
Dry Ice Investigations Exemplar (40 minutes)
Conclusion and Quick Write (10 minutes)

Total Workshop: 2 hours

Partner Share: Why is Talking Important for Learning? (5 minutes)

Note: *Since one of the purposes of this session is to encourage teachers to foster cross-discussion, or student-to-student discourse in their classrooms, the instructor should encourage and model this during the session as often as possible. For example, when a participant makes a comment, the instructor can invite other participants to comment on that comment (e.g.: "What do you think of that comment?" or "Does anybody have a different opinion or different idea?" During these exchanges, the instructor can also encourage the participants to address one another rather than the instructor.*

1. Introduce Partner Share. Tell participants they will be discussing two questions to get them thinking about the session's topic—Classroom Conversations. Have participants find a partner near them. Tell anyone without a partner to raise their hand, and make adjustments as necessary. If you have an odd number of students, you may choose to partner with a student, or have a group of three.

2. Begin the Partner Share. Display the slide of the two questions for participants to discuss:

- Why is talking important for learning?

- What strategies might be used in a classroom to encourage discussion between students?

3. Seat participants in small groups. After about five minutes, ask participants to form groups of approximately six people.

Jigsaw: Research Cards on Talking and Learning (30 Minutes)

1. Introduce Jigsaw activity. Tell participants each small group will receive a few research cards. Each card features a piece of information from research about the connection between talking and learning. Each group member is responsible for carefully reading one of the cards and explaining the information to their small group. Like a jigsaw puzzle, each member of the team is in charge of one of the "pieces."

The Research Cards are:

#1 Zone of Proximal Development (ZPD) - Vygotsky
#2 I-R-E (Initiate, Respond, Evaluate)
#3 Dialogic Classrooms - Nystrand
#4 The Role of Dialogue in Learning
#5 Peer-to-Peer Discourse
#6 Value of Guidance in Learning Science
#7 Science as a Sociocultural Process - Lemke

Note: *Each member of a group six people is responsible for one card, since there are seven cards. If there are less than seven in a group, each member should take responsibility for one of the cards, and if they have extra time they may look at the other cards.*

2. Each member leads a brief discussion about one research card. Display *Jigsaw Activity* slide. Tell them that after each group member reads and shares the information from their research card, they should tell the group their own thoughts about the topic. Then they will invite group members to discuss the topic on the card, including:

- anything they find confusing
- questions or issues they have
- how this information might influence classroom teaching.

During this discussion, each member should hold on to, and be in charge of, their research card. If they have less than six people in their group, they can discuss additional research cards. They should take turns sharing and discussing each research card until you tell them to stop.

3. Large group share. After about 15–20 minutes of discussion, ask each group to share out any issues, ideas, or questions that came up during their small group discussion. Specifically ask how the information from research could inform their teaching.

4. Explain rationale behind jigsaw activity. Tell participants that this type of jigsaw activity is often used with children in classrooms, and is meant to encourage collaboration and discussion in small groups. Having each member responsible for the information on their card and leading the discussion about that information, can help keep everyone involved in the discussion, and prevents any one person from dominating the group.

Watching and Discussing a Video Transcript (35 Minutes)

1. Introduce video. Explain that they will now watch a video from the *Windows on the Classroom* series in which a teacher is leading kindergarten and first grade students in their investigation of how potatoes grow. Explain that although the investigation included activities, the video is primarily focused on discussions in the K–1 classroom led by the teacher.

2. Set expectations for viewing video. Ask participants to observe and think about how the teacher encourages discussion among the students. How does what she does influence student participation in sharing their ideas and questions about potatoes? Start the six-minute video.

3. Explain how the transcript has been coded. When the video has ended, pass out a copy of the transcript to each participant. Pass out the *Coding Transcripts* handout, and explain that the transcript has been "coded" in order to identify different types of moves a teacher can make during a discussion. Explain the various codes listed on the handout.

4. *Think:* Participants think about questions. Display the following questions on the next slide, and ask participants to look at their coded transcripts as they quietly think about each one:

- What moves did the teacher make and what were the results?
- To what degree did the teacher generate student involvement?
- Were there any instances of students talking directly to each other?

5. *Pair:* Partners discuss questions. After a few minutes, tell the participants to now discuss these questions with a partner. Encourage them to cite evidence from their coded transcripts during their discussions.

6. *Share:* Large group discussion. Get the entire groups' attention, and ask participants to share some of their thoughts with the class. Make sure to provide accepting responses and encourage participants to elaborate on and clarify their ideas. When you're ready to conclude the discussion, point out that examining the pattern of teacher moves can help us understand their positive and negative effects on student discourse.

7. Explain purpose of *Think, Pair, Share* activity. Point out that the activity they just conducted is often called, Think-Pair-Share, and it is very effectively used in classrooms with children. Explain that the *Think* portion of the activity is meant to encourage students to access their own knowledge or to formulate their ideas about a topic or question. The *Pair* portion gives students the opportunity to express and compare their ideas in a safe one-on-one setting. The *Share* portion then allows the whole class to benefit from hearing what others have thought about the topic.

Exemplar Activity: Dry Ice Investigations (40 minutes)

Introducing the Dry Ice Investigation

> ***Note:*** *If obtaining or using dry ice is problematic given your situation, you can substitute a different open investigation of interesting materials or organisms.*

1. Introduce dry ice lesson. Explain that they will now experience an exemplar activity and discussion, which is appropriate for grades 5–8, from the GEMS guide, *Dry Ice Investigations*. Tell them that this lesson is intended to demonstrate how a discussion can help support student meaning-making.

2. Observe dry ice. Explain that they will be investigating the dry ice as if they have never seen it before. During this activity, they will be finding out all they can about dry ice. They will be conducting their own ***safe*** investigations of dry ice. Hold up a piece of dry ice, and ask them to describe it as if they have never seen it before. Tell them to call out, and not raise hands for these observations.

3. Use scientist's perspective. Urge them to continue with this same perspective as they conduct their dry ice investigations—as if they've never seen or heard of dry ice before. They should try to come up with explanations for anything interesting they observe during their investigations. No explanation will be considered too crazy or silly. This is meant to be an exercise in making observations, conducting tests, and coming up with tentative explanations for what they observe, not an exercise in repeating information they've heard before. Tell them that if anyone has prior knowledge about dry ice, to refrain from sharing that information until after the exemplar.

4. Explain "teacher" role for each group. Tell them they will start off with everyone investigating, but after a little while you'll tell them to choose one person in their group to play the part of a teacher. The "teacher's" role will be to ask questions of other members of the group—to encourage the "students" to make observations, conduct investigations, and try to explain what they are observing.

5. Introduce materials they will use. Briefly describe each of the materials they will have available for their investigations:

> **a. Dry ice supply:** Tell participants that a limited supply of dry ice is available, and that they need to use it sparingly. Tell them that it's much more interesting to use small amounts of dry ice in a variety of different investigations than to dump it all into one large investigation. Instruct them not to simply keep dumping more dry ice into an investigation just to make it bigger.
>
> **b. Warn about touching dry ice:** Tell participants that dry ice is very cold and can produce "frostbite" if touched by their bare hands. Ask them to be careful with the dry ice at their tables—trying to contain it on their trays, so that they don't touch it accidentally. Explain that if they touch it accidentally for just a second or two, it's not harmful, but if they touch it for longer than that, it can be harmful.

> ***NOTE**: Be sure **NOT** to model unsafe behaviors with dry ice yourself, such as tossing it back and forth in your bare hands, or putting it in your mouth. These behaviors are not only examples of bad role modeling for young people, and might inspire them to be unsafe with the dry ice, but they are also forbidden in many schools, since they can result in injury.*

c. Tweezers and spoons: Let participants know that anything besides the dry ice itself is safe to touch with their bare hands. Point out the tweezers and spoons for safe handling of dry ice.

d. Water: Show participants where they can get cold and hot water. Demonstrate how to carry the hot water *with two hands* back to their tables, as a reminder to themselves that they are carrying something very hot that could hurt someone. Warn them not to touch the hot water or the sides of the coffee pot.

e. Cups: Show participants which cups they may and may not use for hot water.

f**. Flasks/vials, balloons and sealable plastic bags:** Warn participants that they are not to put dry ice in airtight containers, unless they are sealable plastic bags, or if they are sealed with a balloon (such as a plastic vial with a balloon over its mouth). **Also warn them that they are not to use glass containers with dry ice.**

> ***Warning:** As noted previously, If dry ice is placed in an airtight container, pressure from the gas released from the dry ice may burst the container. If the container is glass, this can be particularly dangerous.*

Conducting the Dry Ice Investigation

1. Distribute materials. Ask a volunteer from each team to get a tray of equipment for their team.

2. Distribute dry ice. Distribute a small amount of dry ice powder and tiny pieces to each team (~1 teaspoon). As they use it up, periodically distribute more dry ice as needed, giving each table the same amounts to be fair. The less you give them at first, the better they tend to be about making more detailed observations and not wasting it. Give each team about 2 teaspoons full the second time you distribute, and keep giving about twice as much as the time before each time you come by.

3. Assist groups as they investigate; pass out *Dry Ice Challenges* after about 10 minutes. Circulate to all groups, **ask questions**, lend a hand, make suggestions, and enforce safety rules. After about 10 minutes of investigation, distribute the *Dry Ice Challenges* sheet to one of the course participants at each table. Explain that these are some challenges for them to try.

4. One participant in each group begins playing "teacher" role. After about five more minutes, tell each group to choose one person to play the "teacher" role, and ask questions of their fellow participants to encourage observations, investigations, explanations, and thinking.

Discussing Dry Ice Investigations (10 minutes)

1. Conclude dry ice investigations. At the designated stopping time, use a signal to get their attention (you could tell them to "freeze.") You may also want to give instructions for cleaning up materials.

2. Gather participants for discussion. Have participants either remove the materials from their tables or move to a discussion area.

> ***Note:*** *Even with adults, it's very challenging to conduct a discussion when dry ice is within reach!*

3. Lead discussion on discoveries and explanations. Using the **Discussion Map** (as introduced in the Questioning Strategies session) as a general format, invite participants to share discoveries. Also ask them to share possible explanations and reasoning for observations, accepting all ideas, and encouraging participation.

Of course, discussions are unpredictable and never actually fit neatly into a "map." You will need to listen to ideas and improvise as you go, following participants' interest and lines of reasoning, while providing focus to the discussion as necessary. What's most important is that the topic be interesting (it is!), and that the instructor sets a tone in which participants feel that their ideas are desired and valued. It's also important that they feel that the question is truly broad, and that the teacher is not trying to get them to give particular answers. **See the sample discussion map in the box on the next page for an idea about how this discussion might proceed.**

> ***Note****: Since every participant is likely to have an enthusiastic response to the question, "what is something interesting you saw during your investigations," this provides an excellent opportunity to ask this of a participant who has not participated much in discussion—without waiting for them to raise their hand. Doing this also models the use of a strategy participants can use with reluctant-to-speak children in their classrooms.*

4. Lead a discussion about what influenced the dry ice investigation and discussion. Ask the following questions to promote discussion about factors and teacher moves that may encourage or inhibit exploration and discussion:

- How would you describe the investigation and discussion we just had?
- What factors encouraged exploration and discussion in this activity?
- How did specific moves made by instructors influence participation and the discussion?
- Can you think of any teacher moves – beyond what we did today - that could potentially inhibit exploration and discussion?
- In what ways did these discussions illustrate how learners can build meaning or understanding through discussion?

> ***Note:*** *Depending on the amount of time you have, and the patience of participants, you'll likely need to cut off portions of the dry ice discussions before reaching full resolution.*

Using a Discussion Map to Discuss Dry Ice Discoveries and Explanations

Ask a broad question:

• Ask participants to share something interesting they saw during their investigations.

Example:

Instructor: What is something interesting you saw during your investigations?
Participant: Some pieces of dry ice floated, and some sank.

Ask for evidence or explanation:

• Ask follow-up questions to clarify, as necessary.

Example:

Instructor: Was there anything different about the pieces of dry ice you observed floating or sinking?
Participant: They were different shapes and different sizes.
Instructor: Did you notice that any particular shapes or sizes tended to float or sink?
Participant: Yeah, the small ones floated and the big ones sank.
Instructor: You noticed the small ones floated and the big ones sank?
Participant: Yeah.
Instructor: Did the shape seem to make a difference?
Participant: I don't think so.
Instructor: What do you think might be causing the small ones to float and the big ones to sink?
Participant: I think they're just lighter, so they float.

Ask for alternative opinions or ideas:

• Ask other participants what they think of this explanation.

Example:

Instructor: Does anyone want to say anything about this explanation, or offer a different explanation?
Participant: I agree, I think they're lighter, but I think they float because gas from the dry ice makes like a bubble that pushes the lighter pieces of dry ice up. I think the bigger pieces are just too heavy for the bubble to lift.
Instructor: Does anyone want to say what they think of this explanation?

Bring the discussion back to the main topic:

• Ask for other interesting things they noticed during investigations, while keeping them focused on what has been discussed so far.

Example:

Instructor: Did anybody else do any other interesting investigations with dry ice, particularly any that had to do with dry ice floating or sinking, or dry ice and bubbles?

Conclusion and Quick Write (10 minutes)

1. Describe different discussion activities modeled during the session. Tell participants that there have been many different discussion strategies modeled during this session, all of which can be used with the students they teach. Point out that most of the discussion that they've been involved in during this session has been student-to-student discussion. Point out the following activities or strategies you modeled:

- Partner Share
- Jigsaw
- Think, Pair, Share

- Large group discussion using a Discussion Map

2. Introduce Classroom Discussion Activities handout. Display the *Classroom Discussion Activities* slide and distribute the handout. Explain that in addition to paying attention to teacher moves, it's helpful to structure classroom activities in ways that can encourage and enhance discussion. Briefly describe the activities on the handout that were not modeled during the session.

3. Quick Write on applying what they have learned to their teaching. Ask participants to gather their thoughts from this session in writing using the following prompt to help them personalize what they learned about conversations and to think about how they might apply it to their practice.

> Describe changes you could make in your teaching to promote conversation. Cite specific strategies you would use and detail possible responses you would expect from your students.

Optional Homework Assignments:

- Read and discuss. Scott, et al., 2006. p. 608–613. The tension between authoritative and dialogic discourse: a fundamental characteristic of meaning making interactions in high school science lessons:

  — What makes questions so important in learning and teaching?

  — When, how and why do you use questions in your practice? (What is your purpose for asking questions?)

- If you have the time and equipment, have participants video each other while teaching, type out transcripts of what was said, then code them.

Handouts

— Research Cards

— Video Transcript

— Coding Transcripts

— Classroom Discussion Activities

Research Card #1:

Zone of Proximal Development (ZPD) - Vygotsky

Constructing knowledge requires intellectual support. Without guidance, a learner, and children in particular, may not be able to make sense of concepts and potentially leave an interaction with an incomplete or incorrect understanding of an idea (Grandy, 1997; King, 2009; Klahr & Nigam, 2004). **A learner's potential—with such guidance—has been called the "zone of proximal development" or zpd (Vygotsky, 1978). The zpd concept addresses how experienced individuals can help less experienced learners extend their learning beyond where they are able to go on their own based on their physical or developmental level.** "The zpd is the area between what a person can accomplish on their own, to that which they could achieve with the help of someone more experienced" (Hohenstein & King, 2007).

Research Card#2:

IRE (Initiate, Respond, Evaluate)

In what Mehan (1979b) calls an IRE pattern, the teacher initiates the conversation with a question or comment, the student responds, the teacher evaluates the response, and then repeats the pattern with another question.

IRE example:
Teacher: Is this a solid, liquid or gas? (Initiate)
Student: It's a liquid. (Respond)
Teacher: Yes, it is a liquid. It takes the shape of its' container. (Evaluate)
Teacher: What about this one, is it a solid, liquid or gas? (Initiate)
Student: It's a liquid too. (Respond)
Teacher: No, this one is a solid. (Evaluate)

The turn-taking switches back and forth between teacher and student regularly, though the teacher is directing the conversation because they are asking the questions and determining the correctness of the response. Also, student's response may be short answers, while teacher's evaluation may be long and elaborate on the student's response. The teacher controls the conversation by the topics they allow to be formulated and the "off-topics" they ignore (Eder, 1982).

Research Card #3:

Dialogic Classrooms - Nystrand

"In these classrooms, the teacher validates particular students' ideas by incorporating their responses into subsequent questions, a process Collins (1982) calls **"uptake."** In the give-and-take of such talk, students' responses and not just teacher questions shape the course of talk. The discourse in these classrooms is therefore less predictable and repeatable because it is "negotiated" and jointly determined – in character, scope, and direction –by both teachers and students as teachers pick up on, elaborate and question what students say (Nystrand, 1990a, 1991a). Such interactions often are characterized by **"authentic" questions**, which are asked to get information, not to see what students know and do not know; that is, authentic questions are questions without "pre-specified" answers (Nystrand & Gamoran, 1991a). These questions convey the teachers' interest in students' opinions and thoughts. Hence, in contrast to the "test questions" of recitation, or what Mehan 1(1979a) calls "known

information questions," they indicate the priority the teacher places on thinking and not just remembering. These 'instructional conversations,' as Tharp & Gallimore (1988) call them, or 'substantive conversations,' as Newmann (1990) calls them, engage students because they validate the importance of students' contribution to learning and instruction. The purpose of such instruction is not so much the transmission of information as the interpretation and collaborative co-construction of understandings. In this kind of classroom talk, teachers take their students seriously (Gamoran & Nystrand, 1992)."

Opening Dialogue, Martin Nystrand 1997, page 6-7

Research Card #4:

The Role of Dialogue in Learning

Vygotsky (1978) detailed the importance of discourse by arguing that higher mental functions have social origins that are first expressed between individuals before they are internalized within the individual. In other words meanings are rehearsed and made explicit as a result of conversations and interactions between people before becoming internalized by the individual. In the sociocultural viewpoint, learning relies on conversation. For learners, engaging in conversations can foster more generative thinking and enable them to practice dialogic skills, such as asking questions and communicating ideas in an effective manner. It can be a way for them to process information and make social connections. These thinking and dialogue skills form the basis of active, analytic, individual thought, and allows individuals to develop their ability to communicate their ideas. For educators, conversation can be a window into their learners' prior knowledge, skill-level, personality, previous experience, and ability to articulate ideas.

Research Card #5:

Peer-to-Peer Discourse

Peer talk unfolds in pairs or groups of children unhindered by the inherent asymmetry of adult–child interaction. The more equal participant structure of peer groups may be conducive to both cognitive and pragmatic development. Rogoff (1990) highlights Piaget's (1977) argument that children's discussions with adults are less conducive to cognitive development than their discussions with equals – while the superiority of adults might intimidate children from freely expressing their ideas, other children can provide the opportunity for discussion and reciprocal exchanges, thus promoting the types of social interaction conducive to cognitive development.

Research Card #6:

Value of Guidance in Learning Science

Learning science adds increased complexity to the practice of facilitating discourse. Learning science involves acquiring the language and tools of science and the canonical ways of reasoning in science (Anderson, Holland, & Palincsar, 1997; Kuhn, 1962), and is not possible without guidance and assistance (Scott, et al., 2006). "Learning science, therefore, is seen to involve more than the individual making sense of his or her personal experiences but also being initiated into the 'ways of seeing' which have been established and found to be fruitful by the scientific community. Such 'ways of seeing' cannot be 'discovered' by the learner—and if a learner happens upon the consensual viewpoint of the scientific community he or she would be unaware of the status of the idea" (Driver, 1989, p. 482). Thus it is necessary for science teachers and informal science educators to engage learners in dialogue about their everyday views of phenomena, **and** introduce the science perspective (science content) (Scott, et al., 2006).

Research Card #7:

Science as a Socio-cultural Process - Lemke

…"science is a social process. This is true even when a scientist is physically alone. Whenever we do science, we take ways of talking, reasoning, observing, analyzing, and writing that we have learned from our community and use them to construct findings and arguments that become part of science only when they become shared in that community. Teaching science is teaching students how to do science. Teaching, learning and doing science are all social processes: taught, learned, and done as members of social communities, small (like classrooms) and large. We make those communities by communication, and we communicate complex meanings primarily through language. Ultimately, doing science is always guided and informed by talking science, to ourselves and with others.

Page XI From Talking Science, Jay L. Lemke

Coding Transcripts

The following codes were used to mark teacher statements in the transcript:
- Focused question (FQ)
- Broad question (BQ)
- Evaluation (E)
- Follow-up (F)
- Invitation (I)
- Repeat or Rephrase (RR)

Note: Some teacher statements (e.g., rhetorical questions) don't fall under any of the above categories. This list doesn't represent all the possible conversational moves that can occur, and there are others that can provide for a rich discussion. It can also be helpful to record when the teacher chooses to remain silent and waits for the students to answer a question or follow-up on a statement.

Student statements can also be coded
When students actively participate in a dialogue, their statements and questions can serve the same functions as those of the teacher. It can also be useful to note on the transcript when open-discussion between students takes place.

Focused questions (FQ)
A focused question (also known as a *test, narrow* or *closed* question) is one in which the speaker already has an idea in mind about the answer or range of answers that are acceptable. It serves to confirm student understanding or to resolve a discussion. Teachers often give evaluative responses after an answer to a focused question, to inform the student whether their response was correct or incorrect.

Example: What causes volcanoes to erupt?

Broad questions (BQ)
Broad questions (also known as open-ended questions) have no pre-specified answer the speaker is looking for. In order for a question to work as a broad question, the student must perceive that the speaker is not expecting a particular response and is really curious about their answer. Sometimes a teacher asks a question as if it is broad, but it then becomes clear that the teacher is actually seeking a specific answer to a focused question when the teacher evaluates the responses.

Example: What did you notice?

Evaluation (E)

Evaluations are when the person indicates that an answer is either correct or incorrect. Evaluations can also be non-verbal and often are communicated by the tone of voice.

Examples:

Hmmmm…not exactly
Yes, that's right!
No, that's not correct.

Follow-up (F)

Follow-up questions or statements (also known as *uptake*) are when the teacher (or students) "follows-up" on something someone has said, by either asking them to elaborate and explore an idea they have brought up or asking how they arrived at their understanding. It functions by taking up an idea that has been put on the table and encouraging students to further explore what it may mean or where it possibly came from. Often, another student will respond by following up on the comment thus extending the discussion.

Examples:

So you said that spoons float…what makes you think that?
You noticed it's smoother than before…what do you think made it so smooth?
Tell us more about that

Invitation (I)

When a teacher asks other students to respond to or take up an idea that has been presented. This kind of question is best asked after an idea has been more fully fleshed out, and serves to invite others to participate and think about what has been said. It can also serve to *initiate* a conversation sequence, as described by IRE.

Example:

Student: So the rocks crunch together, break into smaller pieces and turn into sand.
Teacher: What do the rest of you think about that idea?

Repeat or Rephrase (RR)

This response takes place when a teacher either repeats something a student has said verbatim or rephrases it to determine whether they have understood correctly. It can either serve to encourage students to elaborate further or to merely confirm that the comment was understood. If the response is used to summarize or synthesize what the students have been discussing, then it could also be properly coded as Follow-up.

Example:

Student There were no bubbles when it was mixed.
Teacher: There were no bubbles when the solutions were mixed?

Transcript for Potato Video

NOTE: Teacher statements and responses appear in italics, and are indicated by the letter "T." Coding appears in parentheses. Student names are listed when they are specifically addressed by the teacher. Students whose names are not used in discussion are indicated as S1, S2…etc.

T: When we start new areas of study, we usually write down what we already know. And we are going to spend some time talking about potatoes. And I wanna know what you know about potatoes! Adrian, what do you know about potatoes? (BQ)

Adrian: Mmmmm…cook it?
S1: You can eat it.
T: You can cook potatoes…(writes on the board) alright. (RR) *Anyone else have something they know about potatoes?* (I) *Haley…*

H: Um, they grow underground.
T: Oh, Haley! You say they grow underground. (writes on the board) (RR)
S1: Yeah!
Haley: (nods her head) You have to dig 'em up.
S2: And they look like dirt…

T: OK, Jessica…
Jessica: You can plant 'em in a cup with water.
T: You can plant them in a cup with water… (RR) *when you say that, do you mean just the cup?* (F)
S2: And where's the seeds go?
T: Tell me how, tell me what your plan would be. (F)
Jessica: You put water and then, um, put it in a cup and, and, put it next to the window so it can get some sun.

T: OK, so you say plant…them in a cup with water. (RR) *(writes on the board)*
S1: Yeah, but you put soil, soil.
S2: Planting…Where's the seeds in 'em?
S3: And then you have to plant soil.
S1: Dirt!

T: Here we have a couple things, though, about planting…They grow underground. They have to dig them, you have to dig them up. And that you can plant them in a cup with water. (RR) *Nobody has said where they get potatoes. OK where do you get them, Ryan?* (BQ)

Ryan: Uh, you get' em at the store.
T: At the store. (RR) *(writes on the board) Martin?*
Martin: You can grow potatoes.
*T: Oh, so you can just get them from your garden…(*RR)

New segment:
T: I want you to look at this potato… like you have never seen a potato before. Now what do I mean by that? (FQ)
Student: That looks like a rock.

T: That's what I…I want you to really look at it very carefully, and see what you notice about it. (BQ)
S1: And that one looks like…that one look like a…cocoon.

T: Now, I'm gonna give one potato to every two people. So Cary and Kia can share a potato, Germaine & Martin, and really look at it carefully. You can talk about it a minute or two and then we're gonna write a list of what you noticed about it.
(Students talking….)

T: If you can tell me something you can see about this potato…something you observe about this potato. (BQ) *That's my word…observation. Jeremy…*

Jeremy: Oh, they grow uh…
T: Someth..No…(begins to E, but then stops)
Jeremy: …little things all over.
*T: Oh, they grow little things…(*RR)
Jeremy: …with holes you can see 'em. You can see holes.
T: You can see little holes on the outside of it?(F)
S: Those things…that's where you put the toothpicks.

T: Now, when I give you the other potato, I want you to observe it also. Look at it carefully, but see if you can see anything different about the potato I give you this time, from the potato you already have. (BQ) *(Oops, Sean you're right)*

S1: What are those?
S2: I don't know.
Jeremy: I know! That's what I was talking about. These are what those things are with the holes in them!
Jessica: I know - they're planting stuff on 'em!

T: OK raise your hand if you have a comment. Jessica…(I)

Jessica: That these things are planting…
T: What do you mean? (F)
Jessica: Um, I had potatoes that looked like one of these and they're growing…
S: They're sprouts!
Jessica: The potato wasn't in the water, but it still growed in the bag.
*T: So you think that potato's growing… Or when you said some…(*F)
S: It is...it's growing some.
T: OK. You think that, you think that's coming out of the potato or did you think something was put on the potato? (F) *I guess I couldn't quite understand.*
Jessica: I think it's coming out of the potato.
T: *You think it's, you think it's coming from inside and coming out of the potato.* (RR)
Jessica: nodding.

T: OK. What do you want to call that? (FQ?)
Many students answer at once: growing, buds, growing potato
T: What do you want to call it? (I) *You think it's a little grow…a little…a little thing growing on the potato.* (RR) *But just…*
Martin: Nu-uh it's called sprouts.

T: Martin, when you raise your hand you can add to this…So Jessica you said "a little thing grows out of the potato." (RR) *(writes on the board)*
Martin: These are sprouts, that are growing out of these potatoes. Sprouts grow on these potatoes when they come…when they come out of the grounds, they get' em and um…sprouts, sprouts, um, grow.
T: OK. So you wanna, you wanna call these things…are you saying spouts? (F)
Many students at once: Sprouts!!
T: Sprouts, sprouts, sprouts. (RR) *(writes on the board)*
S: We have a hard time with that word.
T: OK. I just didn't get that "r" in there did I? Sprouts are coming out of it. (RR)

Haley: The little seeds on the potatoes…they're, I think they're these…only, um, they're, um, tinier 'cause they haven't grown as much.
T: So even on the first potato, the ones that you could see a little bit, you're saying are just smaller ones of these. (RR)
Haley: Yeah.
T: Now you, you called them something, though. What'd you say that you thought they were? (F)
Haley: I think, um, seed.
T: So you think maybe those are like a seed. (RR) *(writes on the board)*

Classroom Discussion Activities

An important part of the process of learning is having opportunities to talk with others about the topic. These are some activity structures that provide opportunities for students to discuss during classroom time, and that can be used with any topic.

- **Partner Share**

  Pairs of students discuss one or more questions. This very simple strategy can be done with planned questions, or can also be improvised at any point in a lesson. "Turn to a partner and discuss, [insert question here]." It helps keep everyone engaged in large groups, and gives opportunities for everyone to talk about what they are thinking, as well as hear the ideas of others.

- **Jigsaw**

  1. Each member of a small group is responsible for reading a piece of information. Each piece of information is relevant to the topic they are to discuss. Each member of a group is responsible for carefully reading one of the cards. Then they take turns explaining the information from their card to their small group. Like a jigsaw puzzle, each member of the team is in charge of one of the "pieces."

  2. Each member leads discussion about information on his/her card. One group member shares the information from his/her research card, and tells the group their thoughts about it. They may include:
  - anything they find confusing about it.
  - any questions or issues they have about the topic on the card.

  They should also invite group members to discuss the topic on the card.

- **Think-Pair-Share**

  1. Think: Give students an interesting broad question to think or write about briefly.
  2. Pair: Pair students, and ask them to discuss the question(s) with their partner.
  3. Share: Lead a large group discussion about the topic.

- **Thought Swap**

  1. Choose a series of broad questions on a topic that will be interesting to discuss.
  2. Line up participants and establish partners. Have participants stand shoulder to shoulder to form two parallel lines, so each person is facing a partner. Participants standing side by side should be at least 6" apart.
  2. Explain procedure for discussing questions. You will be providing a question for them to talk about with their partner across from them. They will have about a minute to talk. You will signal them to be quiet to prepare for the next question or statement by gently tapping on the shoulder the first two participants at the end of the lines (the "tap of silence"). These two will then pass the tap on down the line, till the entire group is quiet.
  3. Begin the thought swap. Pose the first question for participants to discuss
  4. Share responses with group. After about a minute, tap the first two participants at the ends of the lines and wait for the entire group to become silent. Repeat the question. Ask a few participants to share with the large group what their partner told them.
  5. Change partners for discussion. Tell participants which one of the lines will shift with each question, while the other remains in place. Tell the person at the end of one line to walk down and rejoin the line at the opposite end. Have this line now shift one position to the left so everyone is facing a new person. Everyone now should have a new partner.
  6. Do the same with the other questions.

- **Tape recorders**

  1. Pair up students. Assign partners, with one student as "talker," the other as "tape recorder."
  2. Explain roles. The "talkers" role will be to say all they can think of about the topic you give them, until you say, "stop." The "tape recorders" job will be to listen to everything she says until you announce, "stop," then try to repeat as much of it back as possible, like a tape recorder.
  3. Begin talking and recording. Provide a prompt or a question and tell students to begin discussing. After a couple of minutes, get the group's attention and instruct them to switch roles.
  4. Discuss process. Now tell them to briefly discuss in their teams how it felt to be a "talker" and "tape recorder." After a few minutes, ask for a few comments to be shared with the whole class.

Presentation Slides

— Discuss with a Partner

— Jigsaw Activity

— Transcript Observations

— Classroom Discussion Activities

— Quick Write

Discuss with a Partner:

• Why do you think talking is important for learning?

• What strategies might be used in a classroom to encourage discussion between students?

Jigsaw Activity

- Silently read your card
- Explain to the group what it says and your thoughts about it
- Ask group for comments about:
  - — things they found confusing
  - — questions they have
  - — how this information could influence teaching

Transcript Observations

• To what degree did the teacher generate student engagement and, if so, how do you think she did this?

• What types of teacher "moves" preceded a series of responses made by students?

• What evidence did you observe of student meaning-making during the discussion?

• When and how does the teacher's facilitation open up opportunities for students sense-making?

Classroom Discussion Activities

Partner Share

Jigsaw

Think, Pair, Share

Thought Swap

Tape Recorder

Quick Write

Describe changes you could make in your teaching to promote conversation. Cite specific strategies you would use and detail possible responses you would expect from your students.

Additional Activity

Floating Bubbles Demonstration

If your visiting students are at high school or university level, you may want to demonstrate a phenomenon that is more challenging to explain. Pass out bubble solution, tubs and straws, and demonstrate how to place a large amount of dry ice in the tub. Dip a straw in the solution and gently blow a bubble in the air above the tub, so the bubble floats down into the tub. This will probably take a few tries. The first bubble might sink quickly, as it often has a drop of bubble solution on it that makes it heavier. Try blowing a second bubble without re-dipping your straw. Be sure not to blow into the tub, or else the dry ice gas will be blown out of the tub.

Participants should observe that the bubbles float on the layer of carbon dioxide gas, created by the subliming dry ice. If they observer carefully and long enough, they may notice that over time the bubbles slowly sink and get bigger.

Note: Do not explain to the participants what is going on. That's the mystery for them to solve! If the bubbles are very small, they are less likely to float. Hint for making larger bubbles: If you are using a straw to blow bubbles, blow more slowly, then flick them off the straw.

If you have trouble observing the floating bubbles phenomenon, it may be because the invisible layer of carbon dioxide gas has not accumulated in the tub. Try one or more of the following: Add more dry ice to the bottom of the tub or break up the dry ice into smaller pieces.

If you do this demonstration, see the "Floating Bubble" discussion questions below in the "Wrapping Up" section.

