A Pedagogical Patterns

Teacher Workshop

Boomerang Pedagogical Patterns

Teacher Guide

The term "boomerang" comes from an earlier SRI project called Project WHIRL. In that project, teachers came up with the idea of having individual students and groups generate questions that students then have to answer. Because the questions come back to students, the teachers likened this to throwing a boomerang.

Student questions can help reveal what students believe is important to know, and their questions can reveal their thinking about a concept. At first, students may find it difficult to develop good questions; therefore, the *Contingent Pedagogies* team developed supplementary guidance about how to help students develop questions and answer choices.

The Student-Driven Pattern

A student-friendly version of the question design criteria has been developed to support this pedagogical pattern.

1. **Ask each group to develop two review questions.**

   Ask students working in small groups to develop a Reflect and Review question on a specific facet cluster or goal facet.

   Ask students to write both a "what is/are" question (i.e., one that requires them to recall factual information) and a "how/why" question (i.e., one that requires them to interpret or explain a phenomenon, image, table, or graph by applying a scientific concept).

   Potential observations to use as basis for assessing student thinking:

   - *Students' questions reflect important or key concepts you want them to recall and use in future investigations.*
   - *Students' questions reflect an understanding of the difference between a question that requires recall and one that requires them to identify the correct explanation for a phenomenon.*

2. **Ask students to create answer choices.**

   Ask students to create answer choices for the question. The choices should include the answer they think a scientist might give to the question, as well as responses that are problematic.

   Potential observations to use as basis for assessing student thinking:

   - *Students' goal facets align with scientific understandings but are in their own words (i.e., not copied verbatim from a text or website).*

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- *Students make use of previous class discussions that reflect problematic responses they have heard peers give or that they held themselves.*

3. Ask each group to prepare an explanation for a scientist's response.

Enter questions the group created into the clicker software, and invite each group to prepare an explanation for its scientific response to each question.

4. Ask each student to respond to the questions.

Pose the student questions from each group. Have each student then select the response that best reflects his or her own thinking.

Potential observations to use as basis for assessing student thinking:

- *The distribution of responses to the question provides information similar to that from a teacher-developed question, though the scientific answers may still be problematic (e.g., contain vocabulary and terms used incorrectly or reflect a mistaken idea).*

5. Ask group representatives to share a scientist's response.

Invite a representative from the group that crafted the question to share its perspective on what a scientist's response to the question would be and what a scientist's explanation for the response would be.

Potential observations to use as basis for assessing student thinking:

- *Students' explanations reflect a scientific understanding of the process or phenomenon.*
- *Students' explanations reflect all goal facets relevant to the question, not just one goal facet.*

6. Ask class to refine the scientist's response.

For any response that is supposed to be a scientist's response but is not accurate, invite the class to refine the response together so that it is accurate.

Potential observations to use as basis for assessing student thinking:

- *Students' explanations reflect a scientific understanding of the process or phenomenon.*
- *Students' explanations reflect all goal facets relevant to the question, not just one goal facet.*

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The Teacher-Driven Pattern

This routine may be used instead of the student-driven pattern, if there are concerns about using a student-generated question.

1. **Ask each group to answer a review question.**

   Provide groups of students with a Reflect and Revise question written by the Contingent Pedagogies team for which they will generate student responses.

2. **Ask each student to create answer choices.**

   Ask students to create answer choices for the question. The choices should include the answer they think a scientist might give to the question, as well as responses that are problematic.

   Potential observations to use as basis for assessing student thinking:

   - *Students' goal facets align with scientific understandings but are in their own words (i.e., not copied verbatim from a text or website).*
   - *Students make use of previous class discussions that reflect problematic responses they have heard peers give or that they held themselves.*

3. **Ask each group to prepare an explanation for a scientist's response.**

   Enter questions the group responses into the clicker software, and invite each group to prepare an explanation for its scientific response.

4. **Ask each student to respond to the questions**

   Pose the student questions from each group. Have each student then select the response that best reflects his or her own thinking.

   Potential observations to use as basis for assessing student thinking:

   - *The distribution of responses to the question provides information similar to that from a teacher-developed question, though the scientific answers may still be problematic.*

5. **Ask group representatives to share a scientist's response.**

   Invite a representative from the group that crafted the question to share the group's perspective on what a scientist's response to the question would be and what a scientist's explanation for the response would be.

   Potential observations to use as basis for assessing student thinking:

   - *Students' explanations reflect a scientific understanding of the process or phenomenon.*
   - *Students' explanations reflect all goal facets relevant to the question, not just one goal facet.*

6. **Ask class to refine the scientist's response.**

   For any response that is supposed to be a scientist's response but is not accurate, invite the class to refine the response together so that it is accurate.

   Potential observations to use as basis for assessing student thinking:

   - *Students' explanations reflect a scientific understanding of the process or phenomenon.*
   - *Students' explanations reflect all goal facets relevant to the question, not just one goal facet.*

Elicitation Pedagogical Patterns

Teacher Guide

Students bring experiences and ways of thinking they have learned to help them make sense of any new concept taught. Eliciting the thinking students bring is an important first to addressing any problematic ideas and gaps in understanding. The "before-you-begin" questions are designed to elicit facets of student thinking and provoke students into fresh thinking about the investigation that they are about to undertake. Where possible, the questions rely on a context with which students may be familiar, either from everyday life or from an earlier investigation.

The student-driven version of this pedagogical pattern presents questions in an open-ended format, and the teacher-driven version presents questions in which all the answers reflect some aspect of goal facets. The student-driven version is ideal for eliciting students' own thinking. The teacher-driven version presents answer choices to students. Students will likely take some time getting used to a pattern in which there is no single "right answer," but in which the idea is to present the thinking behind multiple answers that could reflect a scientific understanding of the concept.

The Student-Driven Pattern

1. **Pose a "before you begin" question.**

   Pose the elicitation question as an open-ended question and ask students to write an individual response to the question.

2. **Ask groups to discuss and agree upon a single response in small groups.**

   Divide the class into small groups of about three or four students. Ask each group to discuss its responses and then write a single response that represents the best thinking of the group. Groups may use consensus or vote to arrive at a response. The response selected or written by the group should reflect the best thinking of the group to date, or the most persuasive reasoning.

   Potential observations to use as basis for assessing student thinking:

   - *Students draw on their everyday experiences or past investigations in constructing a response.*
   - *Students' reasoning in small group discussions reflects a goal facet related to the question.*
   - *Students try out language and terminology they have learned from an earlier investigation in formulating a response.*

3. **Ask each group to prepare an explanation for its response.**

   Enter the group responses into the clicker software and invite each group to prepare an explanation for its response. The explanations students prepare will become visible in the class discussion of the clicker responses.

4. **Ask each student to reanswer the question.**

   Pose the elicitation question again, this time with each group's idea as a separate response option. Have each student then select the response that best reflects his or her own thinking.

   Potential observations to use as basis for assessing student thinking:

   - *Students' responses reflect one or more goal facets.*
   - *Students tend to choose an answer that better reflects a scientific understanding of the concept, even if their group did not create that response.*

5. **Ask class to compare and contrast group responses.**

   First invite students as a class to identify responses that are similar and ones that are distinct, and then invite a representative from each group to discuss the reasoning behind each response.

   Potential observations to use as basis for assessing student thinking:

   - *Students bring relevant experiences either from their everyday life or from previous investigations to help them reason.*
   - *Students apply concepts from previous investigations accurately to respond to the question.*
   - *Students can recognize subtle and large differences between any two groups' reasoning.*
   - *Student interest in exploring ideas is provoked in the discussion.*

The Teacher-Driven Pattern

1. **Pose a "before-you-begin" question.**

   Pose the elicitation question using the response options developed by the Contingent Pedagogies team.

   Potential observations to use as basis for assessing student thinking:

   - *A number of students select each answer choice, indicating confidence in their understanding of some aspect of the question.*
   - *The distribution of student responses reveals which goal facets are well understood by students and which ones they must learn during the course of the investigation.*

2. **Ask group representatives to explain what makes each response reasonable.**

   Invite representatives to discuss the reasoning behind each response that has votes.

   Potential observations to use as basis for assessing student thinking:

   - *Students draw on their everyday experiences or past investigations in constructing a response.*
   - *Students' reasoning in small group discussions reflects a goal facet related to the question.*
   - *Students try out language and terminology they have learned from an earlier investigation in formulating a response.*

3. **Make a chart that records the class's consensus of what they agree that they know, how groups' reasoning differs, and how they might come to know the answer to the question posed in the investigation.**

   Construct a public chart using student input, after bringing the discussion of reasoning to a close. The chart should have three sections:

   - How We Agree
   - How Our Groups' Responses Differ
   - How the Investigation Can Help Us Learn More

   Potential observations to use as basis for assessing student thinking:

   - *What students say they know aligns with what you judge them to know.*
   - *What students say they want to learn about aligns with what you judge them to need to learn in the investigation.*

Model-Based Reasoning Pedagogical Patterns

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Contingent Pedagogies

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Reasoning with models is at the heart of science. The geosciences especially rely on models and modeling, since the phenomena geoscientists' study often unfold over long time periods and vast distances.

A model-based reasoning pedagogical pattern engages students in interpreting, using, and recreating models. The Contingent Activities follow this pattern, so that students having difficulty developing an understanding of concepts and processes from investigations can gain practice with linking observable phenomena to a concept that explains or accounts for what they can observe.

The Model-Based Reasoning Pattern

1. **Review key characteristics of a model.**

   Prompt students about key characteristics of a model:

   - Represents things that cannot be seen (easily).
   - Involves cycles of refinement as new evidence is gathered.
   - Is not a perfect representation of a phenomenon.

   In building models, students should:

   - Represent in visual form what is presented in text or tables, using labels as appropriate.
   - Revise their models after getting feedback from peers.
   - Expect that their models will not be perfect.

2. **Present a model to students.**

   Show a model to the class. The model could be a contour map, a geologic map, a cutaway of the interior of the Earth, or an animation.

3. **Ask students to interpret or explain models.**

   Students interpret or explain a visual model by writing a response to a pair of questions. One question should focus on what students see, and a second question should ask students for an explanation of what they see.

   Potential observations to use as basis for assessing student thinking:

   - *Students accurately describe the meaning of map symbols, labeled processes, or images.*
   - *Students accurately locate a feature or process on an image or animation (e.g., a particular kind of landform on a map).*
   - *Students accurately explain what is being represented in a model of dynamic Earth processes.*

4. **Ask groups to share interpretations with class.**

   Each student group shares what they have written for the class to discuss. The teacher asks the other groups the following questions, depending on the nature of the task:

   - How do the interpretations of [X] feature compare across the groups?
   - Why did Group A place [Landform X] on this place in the map? (*Continue until all groups have explained their reasoning.)*
   - What of the model shown did every group put in their explanation? Which parts did some groups put in but not others?
   - Do you disagree with anything a group put in their explanation? If so, explain.

   Potential observations to use as basis for assessing student thinking:

   - *Students identify appropriate strengths and weaknesses of peers' interpretations of models.*
   - *Students' explanations reflect scientific understandings of the processes depicted in the model.*

5. **Ask students to create a new representation.**

   Students return to their groups to:

   - Represent the process in the model in a new way (e.g., in a cartoon or storyboard).
   - Make a prediction that requires them to apply what they have learned about the process to a new context

Potential observations to use as basis for assessing student thinking:

- *Students represent and label key processes in their own models that are consistent with the models initially presented to them.*
- *Students use models to make reasonable predictions about Earth's processes.*

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Reflect and Revise Pedagogical Patterns

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Contingent Pedagogies

Students can improve their understanding of concepts when they have the opportunity to reflect on what they know and to revise their thinking. The anonymous clicker display provides students one source of feedback that can occasion reflection. The class discussion of responses provides an opportunity to engage in public reflection and to revise ideas. Posing a clicker question a second time provides students with the opportunity to apply their revised reasoning and provides teachers with feedback on the effectiveness of the pedagogical pattern in addressing student difficulties.

The Reflect and Revise Pattern

1. **Pose a "reflect and revise" question.**

   Pose a "reflect and revise" question and ask students to use their clickers to respond. Display the distribution of student responses for all to see. Each question includes a response that is the goal facet and other responses that reflect problematic facets.

   So that students can discuss the reasonableness of each response, make sure that the correct response is not indicated when you display the responses.

   Potential observations to use as basis for assessing student thinking:

   - *Students select the response associated with a goal facet when they have a deep understanding of the concept.*

2. **Invite different students to explain what makes each response reasonable.**

   Invite students to discuss the reasoning behind each response that has votes. You may want to invite students who selected that response, but you can also ask students to put themselves in the position of someone who selected that response and ask them to consider why someone may have chosen that response.

   Potential observations to use as basis for assessing student thinking:

   - *Students provide an explanation for a response that presents evidence and refers to a concept they have learned in the investigation or studied in a previous investigation.*
   - *Students recognize responses that are problematic and can express what would make the response option a response a scientist might select.*

3. **Ask each student to reanswer the question.**

   Pose the “reflect and revise” question again. Have each student then select the response that best reflects his or her own thinking.

   Potential observations to use as basis for assessing student thinking:

   - *Students select the response associated with a goal facet when they have a deep understanding of the concept.*

4. **Apply the decision rules to decide what to do next.**

   Using the Decision Rules and your observations of their reasoning, select one of the following options:

   - Pose the next question for “reflect and revise” (when nearly all students chose the response linked to the goal facet after reanswering the question).
   - Count off students and create groups in which students discuss the question and the responses (when many students chose the response linked to the goal facet, but a number of students still chose other responses).
   - Divide the class into two groups that reflect the most popular responses and ask the two groups to formulate arguments to convince the other group of their choice (when about half the students chose the response linked to the goal facet, and half chose another response)
   - Lead a Contingent Activity with the students (when most students chose a problematic facet, even after discussion).

5. **Ask each student to reanswer the question.**

   Pose the “reflect and revise” question a third time. After students have responded, invite a student to summarize the class’ understanding of the question.

   Potential observations to use as basis for assessing student thinking:

   - *Students select the response associated with a goal facet when they have a deep understanding of the concept.*