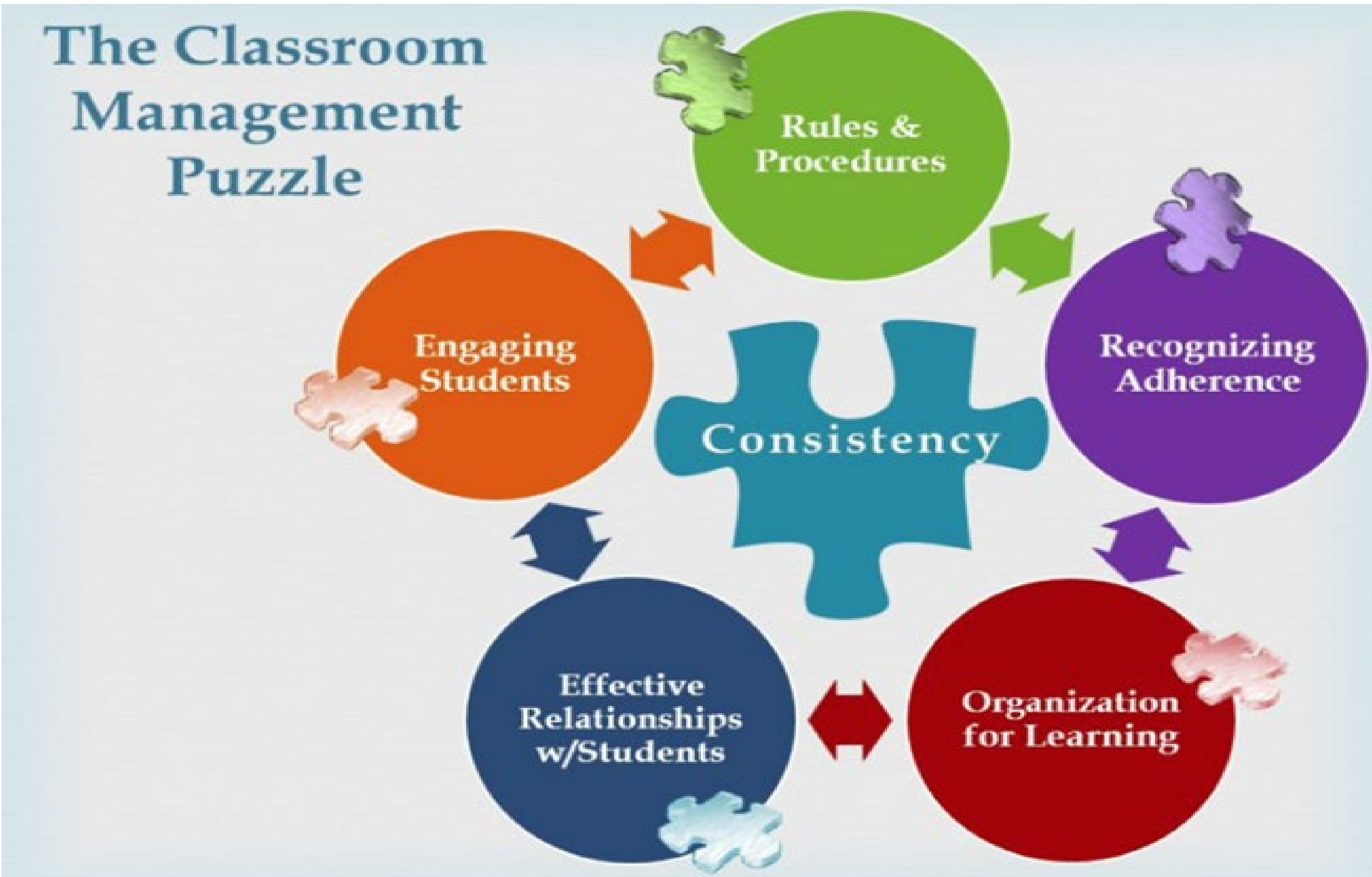
Classroom Management



Notes:

Beliefs and Classroom Practice

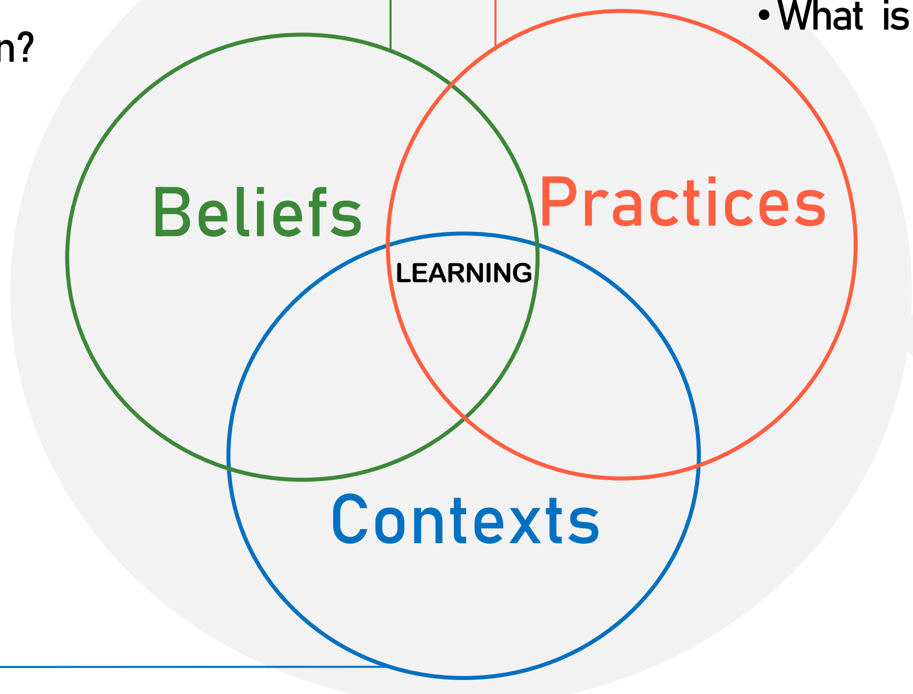
How do your beliefs effect your teaching and students' learning?

Beliefs

- How do students learn most powerfully?
- What conditions are required for powerful learning?
- What is our mission?

Practices

- What is the role of the teacher?
- What is our vision for teaching and learning?
- What is possible in the classroom?



Learning Culture

- How do we support and encourage professional learning?
- How do we attend to the emotional aspects of learning?

Contexts

- How well do we know the students we teach?
- How does technology change the **What** and **How** of learning?
- What are the larger global shifts that should inform our teaching

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Questions are the Answer

A logical questioning strategy for any topic

THE BEST SCIENCE TEACHERS MODEL THE effective use of questions in scientific inquiry. They know that science students who learn both the questions and the logic of science develop the thinking skills and science literacy we all value. Questions also raise new ideas and suggestions, stimulating student thought and action while revealing a particular strand of problem-solving logic.

Teachers seeking such science literacy and thinking skills in their students must develop and use clear and purposeful strategies for deciding which questions to ask, when to ask them, and in what order. To do so, teachers must have an equally clear idea of where to begin questioning, how one question easily leads to another, and where the questions are leading.

Students, often reluctant to express their ideas for fear of rejection, must be presented with clear, nonthreatening questions. A science teacher's strategy for questioning must, then, include ways to ensure that the student will be able to answer that pivotal first question, thus enabling the teacher to learn about the student's thinking and devise further questions appropriate for that particular learner.

Our questioning strategy is designed to provide teachers with one more tool for thinking about questions and their use in classroom science inquiry. Some science students will deal easily with questions at every level while others may never get beyond basic descriptions of current situations. In either instance, a questioning strategy helps teachers determine the next move and fathom what the students know. A questioning strategy also shows students how the teacher goes about asking questions to resolve problems, revealing the teacher's own, experienced, problem-solving logic and strategies.

We begin with a simple mnemonic to assist in remembering one possible logical order for categories of questions: H R A S E.

History
Relationships
Application
Speculation
Explanation

This system is designed first and foremost to be useful to the classroom teacher and at no point is a set of mutually exclusive categories. This strategy is practical, not theoretical. With this in mind, it will be easy to see that a question might often fit into more than one category. What is important, however, is for the order of questions in a particular instance to be logical, begin with few assumptions about the learner, and allow, ultimately, for considerable depth in the conversation.

HISTORY

We begin with History because these questions relate to the student's experience. Students can almost always talk about what they have done. In doing so, they imme-

BY JOHN E. PENICK, LINDA W. CROW, AND RONALD J. BONNSTETTER

diately have success answering the teacher's questions, have multiple opportunities to talk and explain, and can begin to show what they know as opposed to what they do not know. At the same time, the teacher demonstrates that such basic information is necessary and desirable and serves as the logical beginning point for inquiry. We group these questions under History because they are all in the past tense, have already happened, and were personally experienced by the student.

For instance, if students are working on a laboratory activity, some possible History questions include:

- What did you do?
- What happened?
- What happened next?
- What did you do first?
- In what order did you . . . ?
- What procedure did you use?
- What color (temperature, weight, size) was it?
- What made you think of doing that?

While these are relatively easy and nonthreatening questions, all require more than a simple "yes" or "no" response. Getting students to talk is always one of our goals, and HRASE offers significant opportunities for student-teacher conversation. But, as a teacher in Wisconsin pointed out, "These are easy ones. I've always used questions relating to personal history. But, when I would ask students 'Why did it happen?' they wouldn't answer." With this in mind, we avoid the "why" questions altogether and continue our questioning strategy in a more logical and friendly sequence—one where we never bother with that ultimate (and often threatening) question, "Why?"

RELATIONSHIPS

Seeking relationships and patterns is an essential part of the process of science. Thus, our conversations with students must demonstrate and emphasize this necessary aspect. We can easily do this through our questioning behavior. Equally important, students who can describe the History aspects of their activity probably have seen or can invent a variety of relationships and comparisons without too much difficulty. These Relationship questions ask students to compare their activities, findings, or ideas with other activities, outcomes, and students. The only assumption made is that the student worked with the materials and has observed the procedures and outcomes both directly and closely. However, Relationship questions can be a bit more abstract than History questions. Describing relationships leads to recognizing patterns, a major initial step in ultimately devising explanations of phenomena rather than mere descriptions. Some sample Relationship questions are:

- How does this compare to . . . (other students' outcomes, other experiments, other procedures)?
- If ________ happened, what happened to ______?
- Where have you seen something like this before?
- In talking to other students, who else got these same results?
- What order does that usually follow?
- What seems to be a common element in all your findings?
- Where (when, how) do you usually find these?

Students who routinely seek relationships among their observations and ideas are well on their way to making serious scientific explanations. But first they usually do something with their knowledge.

APPLICATION

Applying knowledge is generally acknowledged to be a true test of understanding as well as the surest way to truly know something. As Thomas Jefferson said, "Of what use is knowledge if not applied?" In attempting to apply knowledge, we see our weak spots, make new connections, and view knowledge in new ways, often creating new knowledge in the process. In another sense, applying knowledge allows us to practice and repeat what we know, again firmly cementing that knowledge into our working thoughts and giving us new, additional ways of communicating that knowledge. Knowledge requires making basic observations, seeing relationships, and abstracting ideas to novel situations. Thus, Application requires far more than the prior two categories of questions, is more difficult, and also reveals far more of the student's grasp and depth of understanding of the concepts at hand.

Application questions might include:

- How could you use this?
- What problems could this solve?
- Where can we find examples of this in the real world?
- If you wanted to do ______, how would this idea (knowledge, finding, experiment) help?
- What machine could you build that would do this?

SPECULATION

Here students must go beyond the data and information given, abstracting to new and unusual situations. Extrapolating and imagining future scenarios is as much a part of science as collecting data. In speculating, however, students become creative, literally creating information, some of which can be tested. At the same time, they must hold some variables constant while thinking of what would happen if other variables were manipulated. Speculation requires students to understand a fair amount about how a phenomenon works, not just what they can observe. Equally important is the support of that speculation through evidence, a vital part of the scientific process. Whenever a student proposes a speculative scenario, the listener can legitimately respond with, "What evidence do you have for that?" This is the kind of questioning and thinking that often leads far afield, sometimes productively and sometimes not. But, in either instance, the student is thinking, talking, explaining, and synthesizing new ideas and understandings—all components of science literacy as most describe it. Each of these actions and science literacy are typically among the goals we hold high for our students.

After a student makes an assertion, the teacher might ask a Speculation question such as:

- What if you . . . (changed, eliminated, added, mixed, waited)?
- What would it take to prove that?
- If you wanted to prevent that from happening, what would you do?
- If that's true, then . . . ?
- What might be inside the black box?

EXPLANATION

By this time in a conversation, science students often are asked to do what may be the hardest task in science—communicate an idea, process, or theory to clarify both the nature of the phenomenon and how it occurs. To do so, students must have an excellent grasp of the fundamentals related to the concepts under consideration, see relationships, fit a number of pieces together in an orderly fashion, and visualize a number of possible future scenarios, depending on how the variables are construed. Often, it is useful to ask them to limit their vocabulary or eliminate certain words. For example, one who truly understands how a Cartesian diver works can easily explain it without using words such as *pressure* or *density*. Inability to do so probably signals a relatively weak grasp of the basic concept under consideration.

Some Explanation questions might include:

- How does that work?
- What causes that to happen?
- How would pushing down on the balloon cause the diver to sink?
- How would you change your explanation if I changed this part of the apparatus?
- How would it affect your explanation if I heated the whole system?
- How does your explanation fit this other phenomenon?

SOME FINAL THOUGHTS

Each of our students creates personal images and explanations of events and ideas in science. These personal conceptions are often dramatically incorrect and quite resistant to change. Yet, as teachers, our goal is to help students develop new, more accurate conceptions to replace their old ones. The key word here is *develop*, for we cannot merely give students a new concept or understanding. All teachers can do is create an environment where that particular concept or idea is available for exploration, analysis, and consideration. The teacher and questions play a vital role in this process.

Questioning a student and listening closely to the response allows us to assess what students think and why they have that particular idea. When, as teachers, we know what they think, we can proceed to place the student in situations where the concept can be demonstrated, talked about, questioned, tested, or otherwise explored. The student is more likely to develop ideas congruent with current scientific thinking, for, as was noted years ago, language precedes logic. As individuals develop an ability to verbalize about a phenomenon, they develop logical structures, ways of thinking, related to it. Questions and the resulting thinking, action, and answers greatly enhance this verbal ability.

As we present questions and our students respond, the students come to see the step-by-step logic of our questions, their own questions and answers, and the nature of science itself. This is in sharp contrast to the often large leaps we make when, as experts, we solve problems on our own. Revealing all our logic to our students is vital. Properly used, questions easily fulfill this role. Using the HRASE strategy, not only can we model a logical and useful line of questions, but we can also make the strategy visible by instructing students about its nature and use. If all your students know HRASE well, they will even begin to anticipate your questions.

We have taught the HRASE strategy to two groups of Houston Scope, Sequence, and Coordination participants, more than 60 preservice science teachers, and 200 participants in various workshops in the United States and Europe. We continually get positive feedback about how useful this strategy is in the day-to-day environment of the classroom.

When our students see and understand our instructional strategy, they learn on that much higher plane we all say we are seeking. Remember, students copy your behavior. So, try the HRASE strategy with your students and help them construct new meaning and understanding in science. In doing so, you will find better teacher-student interactions, better student-student interactions, and far more satisfaction in your classroom. ✧

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Effective Use of Questions for Scientific Inquiry

Students are often reluctant to answer questions or express their ideas for fear of rejection or embarrassment. A teaching strategy to address this includes ways to ensure students can answer that first pivotal question, then follow-up with questions appropriate for that particular student. The instructor is able to learn about the student's thinking and then proceed to more complex levels of inquiry.

The following is a tool for developing and using questions to promote science inquiry. These are all open questions (none can be answered by a simple "yes" or "no"), but avoid "why?" which can be overwhelming. The mnemonic **HRASE** can help to remember a logical order for questions (Penick, et al 1996).

History: Students can almost always report what they have done. This is the logical beginning for inquiry and serves as a useful entry point.

Relationships: This type of question asks students to compare two things, ultimately leading to recognizing patterns, an essential part of science.

Application: Applying knowledge to new situations or in new ways is a true test of understanding and allows the student an opportunity to practice and cement what was learned.

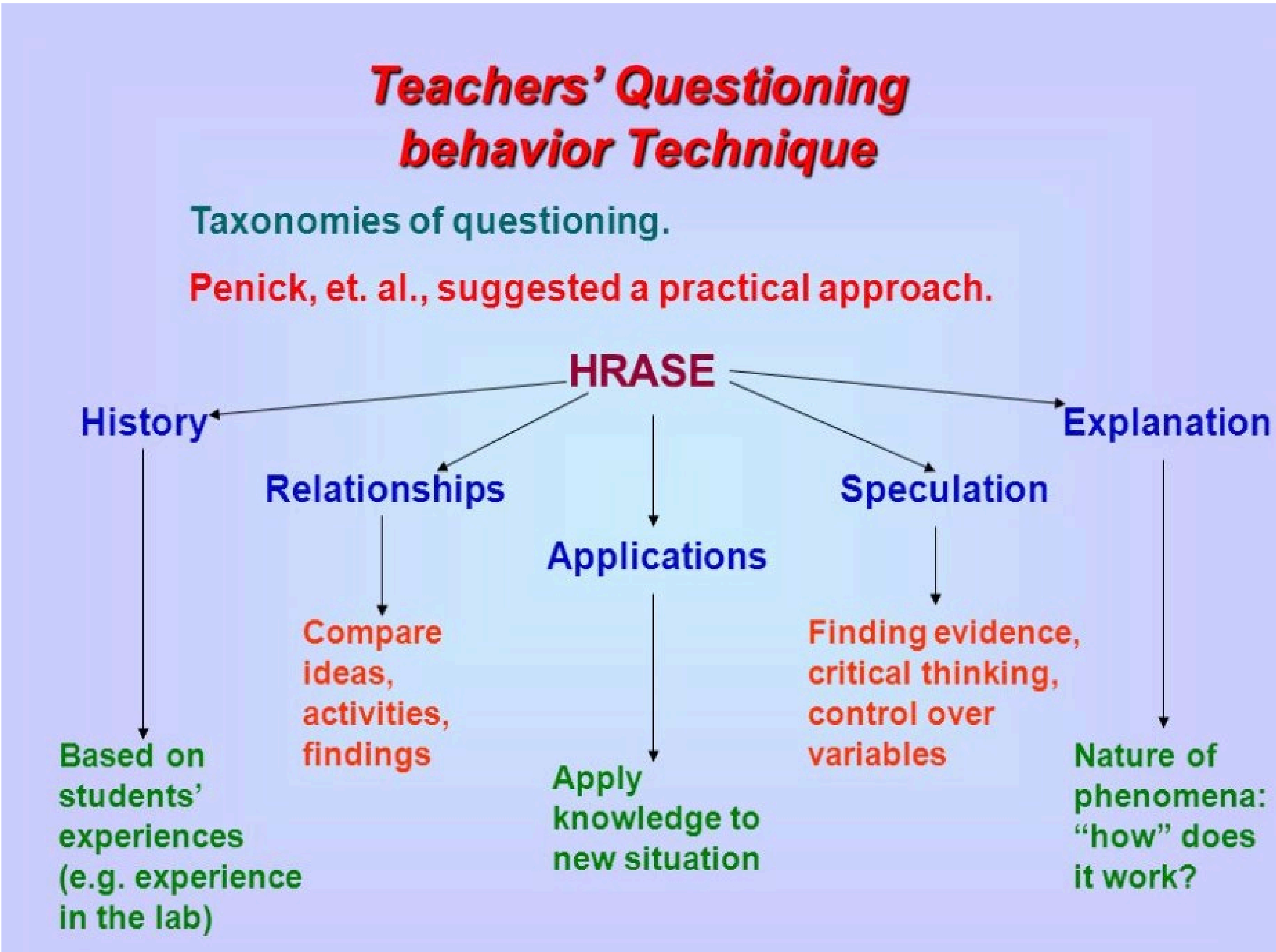
Speculation: Students go beyond the data to extrapolate and imagine future scenarios. This requires a solid understanding of how a phenomenon works and the ability to speculate based on this information is a complex skill. After a student makes a speculation, follow-up questions might include:

Explanation: In the final and most cognitively sophisticated level, a student is asked to communicate an idea, process, or theory to explain the nature of the phenomenon and how it occurs. It can be useful to ask them to limit their vocabulary ("explain so a 10-year-old can understand") or eliminate certain key words ("explain evolution without using the words population, species, or selection")

https://www.usf.edu/atle/steer/teaching-assistants/stem-ta-handbook.pdf

Questioning Strategies

(getting students to think critically)



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- What did you do?
- What happened?
- In what order did you …?
- What procedure did you use?

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- How does this compare to … (other students' findings, other experiments or procedures)?
- Where have you observed something like this before?
- What seems to be a common element in all of your findings?
- If _______ happened, what happened to ______?

Application: Applying knowledge to new situations or in new ways is a true test of understanding and allows the student an opportunity to practice and cement what was learned.
Examples include:

- How could you use this?
- Where can you find examples in the real world?
- What problems could this solve?

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- What would it take to prove that?
- What if you … (changed, eliminated, added, waited …)?
- If you wanted to prevent that from happening, what could you do?

Explanation: In the final and most cognitively sophisticated level, a student is asked to communicate an idea, process, or theory to explain the nature of the phenomenon and how it occurs. It can be useful to ask them to limit their vocabulary ("explain so a 10 year old can understand") or eliminate certain key words ("explain evolution without using the words population, species, or selection").

- How does that work?
- What causes that to happen?
- How would it affect your explanation if I changed___?
- How does your explanation fit this other phenomenon?

Resources and Further Reading

Felder, R.M. and Brent, R. (2016). *Teaching and Learning STEM: A Practical Guide.* San Francisco, CA: John Wiley & Sons.

Hanson, D.M. (2006). *Instructor's Guide to Process-Oriented Guided-Inquiry Learning.* Lisle, IL: Pacific Crest.

Kober, N. (2015). *Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering.* Washington, D.C.: National Academies Press.

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