Developing Scientific Thinking with Students

Background

Thinking 'like a scientist' and scientific investigating are not common activities. Children have innate curiosity to discover the how things work but their ability to investigate is often limited. For example, children often observe one attribute of an object when asked to make observations. Teachers need to guide students to observe carefully using the skills and process of scientific inquiry and the science and engineering practices. In the case of making observations, children need to be encouraged to look beyond color and consider other attributes and use their senses. In addition, children also need to learn that the observations they make become part of claims they can use to describe scientific phenomena. A claim is a response to answer a questions or a solution to address a problem. Scientists support claims with evidence, which is a scientific explanation. One way to encourage thinking like a scientist is to model and facilitate thinking using guiding questions.

These questions can be used through discussions or as focus questions in science notebooks. Questions can be directed or open-ended. Student responses to these questions provides teachers with insights about their understanding and preconceptions about science. When using a notebook, a teacher can respond to a student's idea and build on it or encourage the student to extend thinking. The teacher might further clarify, correct, or compare and contrast a child's ideas; apply a child's ideas to explanations or problems; or summarize and assess a child's ideas through discussion. However, teachers may also probe a child's ideas by reacting to a child's response with a question that requires them or others to think more critically about their response. This may involve asking children to respond to theirs or others' comments for clarification of explanations or data, verification of results or predictions, or justification of hypotheses.

Thinking about varying the types of questions allows teachers to differentiate student thinking and learning at an individual level. The next page consists of a partial list of questions to help the teacher as s/he models and develops scientific thinking.

Sources:

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Encouraging Scientific thinking to make Claims

Attention Focusing Questions help children take notice of details easily overlooked. These types of questions help develop better observation skills. These could be used as part of a discrepant event or during an investigation. These skills become the basis of claims for evidence.

"Have you seen…?"
"Do you notice…?" followed by, "What was it?"
"What does it do?"
"What do you see, feel, or hear…?"
"Tell us what happened…?"
"Would you describe the objects?"
"What happened in the investigation?"

Sentence Starter Example: I see………….. and it feels……………..

Measuring and Counting Questions allow children to use new skills, practice ***mathematics & computational thinking*** and new instruments. These types of questions help build a child's confidence and make better claims from evidence because children obtain an exact answer.

"How many…?" "How long…?" "How often…?"

Sentence Starter Example: I counted…….. They are ……………… cm long.

Comparison Questions help children develop observation, classification, and focus skills. These types of questions also help children to observe differences in shape, size, color, etc… and recognize differences as valuable information. These questions can also guide children as they ***analyze and interpret data*** to "tell what happened" (or draw conclusions) in their investigation.

"In how many ways are these seeds alike and how do they differ?"
"Is this longer, stronger, heavier…than…?"
"How is this situation like (different from) the other one?"
"Which one burned longer?"
"Do you notice any pattern between these...?"
"Which measurements do you think were highest? Lowest?
"Do you think there is a lot of variation between the measurements?"

Sentence Starter Example:

Encouraging Students to Provide Evidence for Claims

Reasoning Questions call for ***constructing explanations***; they can build upon a child's natural curiosity and challenge young minds to think more independently. Questions encourage to think about the cause of an event or to suggest ideas based on science concepts, laws, or rules. This type of thinking promotes them to reason based on evidence. Children will discover that there is no one right answer to these types of questions.

"Why?"
"How?"
"What do you think is the cause of…?"
"Why do you think…?"

“What principles do you think are needed to solve this problem?”
“What do we already know that might help us?”
“Do you have any suggestions about why this happened?”
“Any suggestions about the cause of this?”
“Can you explain why this happened?”
“How would you restate it in simpler terms?”

Explanations Based on Scientific Knowledge/Evidence allows children to see the relevance of facts, concepts, and principles that they are taught. When children are trying to make sense of the possible reasons for their observations or results of investigations; they are ***constructing explanations and analyzing and interpreting data***. They can be guided to consider what they know about science knowledge and evidence or what they may need to learn to explain what they observed. Teachers can help children access prior knowledge and construct explanations that may relate to a discrepant event, conclusions, problem solving situations, and explanations.
“What principles you learned might be involved here?”
“What (rules/principles/concepts) do you think are needed to solve this problem?
“What do we already know that might help us?”
“How do you think this applies to the problem?”
“Why do you think it might have happened?”
“What ideas do you have on why this happened?”

Action Questions help children discover relationships between what they do and the reaction of the materials they are handling. These types of questions can also aid in probing children to explore the properties of unfamiliar materials while considering their decisions based on evidence and new situations; this also lends itself to ***engaging in argument from evidence***. These types of questions may also help in eliciting thoughts about new knowledge from an experience.
“What might happen if…?”
“How can we use this information to explain…?”
“What new problems does this suggest?”
“What are the alternative choices?”
“What are the ways that the choices relate to the values?”
“Who will benefit from my decisions?”
“What are the consequences/risks/benefits from the choices?”

Problem-Posing Questions build a child’s abilities to predict, problem solve, and form simple hypotheses that lead to verification.
“Can you find a way to…?”
“Can you make a sinking object float?”
“Can you make a plant grow sideways?”

Reasoning Questions about the Investigation Process remind children to think about the process or organization of the investigation as they explain what happened. This promotes developing the ability to ***obtain and evaluate and communicate information and*** engage further in ***argument from evidence***.
“Do you need to define or set a limit?”
“Is that conclusion reasonable?”
“How do you know you’re finished?”

"What were the variables that you tested?"
"Would a diagram or sketch help?"
"What was the purpose of the investigation?"
"Would other methods work as well?"
"Does the explanation or model provide an account for how and why the phenomenon happens?"

• What have you decided to investigate? • How many times do you think you need to test to be certain about your results? • How will you remember all of your observations? • How do these results compare with your first test? • How will your group clearly present your findings to the rest of the class?