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Responding to Students in Ways That Encourage Thinking

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Questions are at the heart of communication with students. In many situations a teacher interacts with students by asking and answering questions. During a typical class discussion students are called upon to examine and apply newly acquired concepts. Not all questions and statements made by a teacher, however, promote a productive and useful discussion. Some types of questioning responses can negatively influence the quality of a student's answer. As a chemistry teacher interested in educational psychological theories, I experimented with the use of a paraphrasing technique from a methodology called Teaching for Thinking (1) as a means to promote a more effective discussion in small group sessions. I was surprised to find that some questions and responses commonly used by teachers will inhibit appropriate responses by students. In addition I found that some responses will encourage and elicit student thinking. The application of the Teaching for Thinking methodology has resulted in a noticeable improvement in my effectiveness as a teacher. My students think better and learn more when I use Teaching for Thinking responses.

Consider the following possible teacher responses to a student's incorrect statement about the relative boiling points of ethane, ammonia, and fluorine based on intermolecular forces.

Student: "Ethane has more hydrogen bonds than ammonia, so its boiling point is larger due to the intermolecular forces. Fluorine has only London dispersion forces so its boiling point is less than the other two."

Teacher A: "That's not quite right. Someone else want to try?"

Teacher B: "If you recall, a hydrogen bond is an intermolecular force created under special circumstances. Do you want to try again?"

Teacher C: "You have said that there are more hydrogen bonds in ethane than in ammonia, so the boiling point is larger. Fluorine is lower boiling because it has only London Dispersion Forces."

Teacher D: "What you are saying is that ethane with six carbon-hydrogen bonds, has a higher boiling point that ammonia with three nitrogen-hydrogen bonds, due to the forces between the molecules, and fluorine with only London Dispersion Forces, has the lowest boiling point."

Teacher E: "You have said that the greater number of bonds to hydrogen in a molecule is correlated with larger boiling points. What do you see as the role of bonds to hydrogen in determining relative boiling points?"

Teacher A terminates the interaction with the student and thereby terminates the student's cognitive procession. When a teacher agrees or disagrees with a student, the cognitive procession of a student is unintentionally suppressed by indicating that the student no longer has to think. Additionally, if a teacher rewards a particular response, for example simply saying "That's right, good job!", this reward indicates the student's task is done, and therefore, no more thinking on the student's part is required.

Teacher B allows the student to do some thinking, but because the teacher directs the student towards a preferred answer, the student's cognition is confined to a narrow range. The student may get the right answer, but it will be at the expense of developing his own thinking skills. In addition, it may foster a dependency upon the teacher for direction. Helping a student solve a problem by directing the path through the solution limits the thinking the student has to do in a potentially negative way.

Teacher C has essentially "played back" the student's ideas using key words in the stu-

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In this issue:

C_3 Business:

Nominations are once again being sought for:

President Elect, (to take over presidency in June of 1996)

Treasurer, (2 year term).

Regional Directors, (one or two individuals from each of the regions).

Nominations may be submitted to our secretary, Bob Perkins. Elections will take place at the Annual General Meeting on June 2.

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dent's statement so that the student can think about what he or she has said and decide if that is indeed what he or she meant, This kind of response provides a template where the student can work out his or her own ideas. When a teacher paraphrases a student's response without judging the correctness of the response, the student must rethink his entire answer. This kind of reflection encourages students to think for themselves, and is the core of the Teaching for Thinking interactions. A teacher must listen carefully to what a student says and then respond in such a way that helps the student to reflect on that idea. A response should communicate to the student that the teacher is listening and has respect for the student and his ideas. It provides a cognitive mirror whereby the student must judiciously reexamine his expressed ideas. However, when paraphrasing a student, in neither tone of voice nor word choice should the teacher convey information about the correctness of an answer. If the student's realization that his or her answer is incorrect is based on cues from the teacher, the teacher has done part of the thinking for the student. In order for students to function independently and rely on their own thinking skills, the students must have the opportunity to find and correct their own mistakes even when they do not know a mistake has been made.

Teacher D has highlighted the implicit assumptions in the student's response while paraphrasing the student's statement. This allows the student to rethink his answer and potentially gain new insights into his thinking. When a teacher paraphrases a student's ideas, this obligated the student to thoughtfully work through his or her ideas and assumptions again, and thus will promote a more thorough understanding of these ideas. This type of paraphrase can be used effectively for both right and wrong responses.

Teacher E asks the student to examine the dimensions of the problems and challenges the student's thinking. In asking for more information the teacher encourages the student to elaborate and say a little more about his or her ideas. This encourages the student to continue thinking and expressing his or her ideas.

A teacher's response can either encourage a student to think or discourage a student from thinking., I have found the basic paraphrasing response proposed in Teaching for Thinking to be an effective tool for encouraging students to think. The basic response consists of saying back" the student's idea where the key words of the student's statements are reiterated. The basic response is a productive way of helping the student to hear the idea "played back" and to think about what he or she has said. In addition a paraphrase that highlights assumptions or that provides an interpretation of the student's statement again encourages the student to think and to think beyond what he or she has said.

As I have provided more opportunities for students to think in my classroom through the use of the basic paraphrasing response, I have observed that students function more independently and that more students voluntarily participate. The quality of their thinking improves as measured by their ability to solve complex problems and transfer knowledge to new situations. Based on the success I have found with the Teaching for Thinking methodology in my own classroom, I lecture and direct less, and do more paraphrasing in order to promote and elicit thinking by my students. The satisfaction I gain from enabling my students as thinkers, and therefore learners is one of the reasons I am a teacher.

Literature Cited

1. Raths, L.E.; Wasserman, S.; Jonas, A.; Rothstein, A. *Teaching for Thinking: Theory, Strategies, and Activities for the Classroom;* Teachers College Press: New York, 1986

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The Christmas Quiz – Answers and Winners

Congratulations to our winners:

Ed Neeland
Okanagan University College
Kelowna, B.C.

Hank Publicover
NAIT
Edmonton, Alerta

The Chemistry Department
Capilano College,
North Vancouver, B.C.

Bonnie Bukwa
East Kootenay Community College
Cranbrook, B.C.

Andjelka Draskovic-Lavoie
College de Maisonneuve
Montreal, Quebec

And the answers are:

A – transparents
B – transverse
C – transatlantic
D – transistors
E – transmitts or transmittance
F – transfusion
G – transports
H – transplants
I – Cisko Kid
J – cis-boom-bah
K – cisterns (or cicero)
L – sissies
M – scissors
N – Sicily
O – propyl people ether (purple people eater)
P – paradise
Q – paradox (or paramedics)
R – paragraphs
S – parakeets
T – paradigms
U – metaphors
V – metaphysics
W – orthodox

CCC (Critical Comment Corner)

— Bob Perkins, Kwantlan University College

Over the years I have always enjoyed reading the Provocative Opinion section in the Journal of Chemical Education. I have not always agreed with the authors, but the benefit of each article was to get me thinking. I am proposing that we should have our own version here in C3 News. Having been Editor for 4 years, I know how tough it is to get individuals to submit anything. So, even though being the shy and retiring type, I am prepared to go out on a limb with the first one. I hope it will spur others into taking pen (or mouse) to hand.

"Fact or Theory" – Students Need to be Reminded

I have written previously regarding the preconceived information that our students come into our classes with. One paper dealt with the confusion involving formal charge, oxidation number, and actual charge. I have come to the conclusion that a large part of the problem is a result of the blurring (in the mind of some students) of fact with theory. If one considers the sulphate anion, it has an actual charge of 2^- because of the two extra electrons (50 electrons versus 48 protons). If a student is asked to comment on the charge residing on the S atom, there is no single correct answer. The answer to the question will depend upon the assumptions associated with the particular theory being used to describe the sulfate anion. The shape of the anion (tetrahedral) is a fact (determined experimentally), but the formal charge (a theory based on the assumption of electron sharing between S and O) will depend upon which resonance structure (also a theory based on the assumption that one can indicate the position of all the valence electrons) is drawn. A different answer will result if the question involves the determination of the oxidation number (a theory based on the assumption of the transfer of electrons from S to O) of the S atom. Too many of our students believe that most of what they read in their textbooks in completely factual. The students should be reminded that the only "fact" (something that can be determined experimentally) in this case is the molecular shape of the sulphate ion.

Over the past two years, I have been placing the words FACT and THEORY on opposite ends of the blackboard in the classroom when dealing with such situations. I try to impress upon my students that one must first have some facts before one can formulate a theory to predict the behavior of a different substance in a similar situation, or a similar substance in s different situation. Too often the textbook coverage portrays a nice neat "picture" for a periodic trend. An example of this is with trends in acid strength. Why is HF a better acid that CH4? Most introductory organic textbooks use the rationale that the greater electronegativity of F leads to:

a) a more "polarized" H-X bond
b) a more positive H relative to X
c) a more stable anion (F^-)
d) an acid which more easily gives away H^+

The student reads this, incorporates the information, and then proceeds to the discussion involving the comparison between HF, HCl, HBr, and HI. Suddenly this theory no longer works because the electronegativity argument won't "**give the right answer**", i.e., that the trend in acid strength is HI > HBr > HCl > HF. Here it is the strength of the H-X bond which is the important factor. What has been overlooked by the student is that electronegativity (unlike ionization energy, melting point, boiling point, etc.........) is not a fact but a theory. The relative order is also only apparent if water is not used as the solvent for the pKa determination. Maybe we would be better off to simply say to our students that **HI is a stronger acid than HF because IT IS!!** (i.e., an experimentally determined fact). I am much more concerned that a student be able to predict the outcome of an acid/base reaction using a table of pKa values than regurgitate a theoretical explanation regarding why one compound is more acidic than another. It would certainly be nice to reduce the number of answers like the following:

$C_5H_9CH_2MgBr + H_2O \rightarrow C_5H_9CH_2OH$ rather than $C_5H_9CH_3$

I constantly refer to the words on opposite ends of the blackboard. I insist that a student make the distinction between the two and realize that the facts come first in order to formulate theories which they read in the textbook. I believe that some of my students have gained a better understanding of some portions of the course material as a result of my making such a big deal out of those two simply words: **FACT or THEORY.**

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