# Whiteboarding & Socratic dialogues: Questions & answers

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*The pedagogical practice of whiteboarding is becoming more prevalent across the United States, especially with the Modeling Method of Instruction created by Wells, Hestenes, and Swackhamer, and promoted through the efforts of Arizona State University. The Modeling Method, which has at its heart the use of whiteboarding and Socratic dialogues, has twice been identified by the US Department of Education as an exemplary approach to teaching. With the increasing use of whiteboarding, the author provides here a series of questions and answers about this important constructivist approach.*

**What is a whiteboard?**

A whiteboard is a dry erase board of any small, but convenient, size upon which students can write or draw in order to present concepts, charts, maps, tables, graphs, diagrams, or equations. They are used with dry erase markers, and are easily wiped clean with an eraser.

**What is whiteboarding?**

Whiteboarding is a teaching practice under which students working individually or in groups use whiteboards to describe and explain the results of the observations they have made and/or thinking processes they have utilized. It is an instrument well suited to improving the quality and quantity of scientific discourse in a classroom. Teachers guide students in the use of their whiteboarding work. Typically a cooperative inquiry-oriented project is assigned to student groups. One of the tasks will be the reporting of the groups' findings. Group findings are typically presented by the entire group at the front of class where they might stand the whiteboard on a chalk rest or hang from hooks near the top of the classroom blackboard. Students explain their findings, and ideally will provide multiple representations of the understanding they have developed. The floor is then opened to questions. Teachers and students are allowed to seek clarifications and justifications for student conclusions. Using the whiteboarding approach, teachers hope to change students from "collectors of information to expectant creators of ... coherent understanding" (Wells, Hestenes & Swackhamer, 1995). Whiteboarding is strongly associated with the pedagogical approach known as Socratic dialoguing.



**What educational purpose do whiteboards serve?**

The *National Science Education Standards* (NAS, 1996) note that "inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries" (p. 23). The *Principles and Standards for School Mathematics* (NCTM, 2000) calls for teachers to "encourage students to think, question, solve problems, and discuss their ideas, strategies, and solutions" (p. 18). Whiteboarding can provide an ideal avenue for achieving these goals.

**Is the concept of whiteboarding new?**

Not really. In many ways whiteboarding is a tried and true method that fell by the wayside with the advent of more sophisticated classroom technology. In many ways, whiteboarding harkens back to the days of the one-room schoolhouse when every student had his or her own slate board and chalk for writing, drawing, and computation, and was responsible for sharing with the teacher and fellow students the work that he or she had done. The teaching approaches used with whiteboards today are much more effective.

**Is whiteboarding consistent with authentic best practice?**

Whiteboarding enhances and supports the most desirable teaching approaches. Whiteboarding is an effective approach for teachers implementing three research-based principles identified by the National Research Council (2000, 2005) as critical to learning:

1. **Engaging students' prior understandings.** This is critical to the development of scientific thought, and is central to the teaching approaches known as constructivism and concept change. Preconceptions can strongly influence what students do or do not learn. Whiteboarding allows students to articulate their beliefs and reasoning processes. If flawed

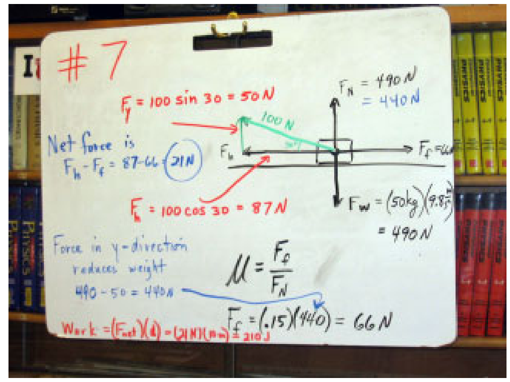
beliefs and improper reasoning are identified, teachers can confront and rectify preconceptions and flawed logic.

2. **Relating factual knowledge and conceptual frameworks in understanding.** Whiteboarding is an approach through which teachers can implement instructional strategies that engage students in inquiry-oriented lessons and labs, and allows for regular classroom discourse, evaluation, and interpretation of evidence. Students come to know not only what they know, but how they know it.
3. **Emphasizing the importance of student self-assessment and autoregulation.** Whiteboarding provides an excellent opportunity for students to learn from and correct their own mistakes, and to learn from the successes and mistakes of others. It also provides strong personal motivation to help students self-assess and auto-regulate before they make oral presentations. A public presentation of what students know and do not know can prove to be highly motivational.

**What is the educational role of whiteboarding as it relates to learning environments and the design of instruction?**

Whiteboarding helps teachers make for classrooms and instructional techniques that are learner centered, subject centered, assessment centered, and community centered.

- ***The learner-centered classroom*** attends to what students think and know, and uses cooperative inquiry practices to help students construct understanding from experiences and logic. Whiteboarding plays a central role in the process by providing a venue for reporting the results of observation and experimentation, and is a forum for formative assessments wherein teachers can identify, confront, and resolve student preconceptions.
- ***The knowledge-centered classroom*** focuses on what is being taught and how it is being taught. The whiteboarding process allows for students to understand why something is known rather than merely believed. It provides a framework through which students have an opportunity to test and confirm or correct their own ideas and reasoning. The approach is one in which emphasis is placed not only on what students think, but how they think. Students learn more as a result of teacher questioning and remarks.
- ***The assessment-centered classroom*** allows students the opportunity to make oral presentations in which they identify and explain step-by-step problem solving practices. They publicly state and justify their conclusions. Whiteboarding allows for fellow students to check and critique others' work during the process. It also affords teachers the opportunity to expose deficiencies in student reasoning, evaluate whiteboarding displays, and student presentations.
- ***The community-centered classroom*** calls for student dialoguing in which students learn to cooperate and communicate. Whiteboarding engenders an atmosphere of questioning. It sets higher expectations for student performance and accountability. Whiteboarding allows




teachers to use class time to discuss student-generated ideas rather than merely presenting information. Whiteboarding engages students with their peers in a collaborative learning community. In a way, whiteboarding allows for more than one teacher in a classroom by allowing students with whiteboards to become fellow teachers as well.

**Who uses whiteboarding?**

Whiteboarding is used by school teachers at all levels and in all subject matter areas. Teachers who are interested in not only what students know, but in how students know what they claim to know, and to what extent they understand what they claim to understand, will make use of whiteboarding. It is not uncommon to see whiteboards used from elementary school through college, and even in professional development activities for teachers. Whiteboarding is perhaps best known today for its use in the Modeling Method of Instruction described more than a decade ago by Wells, Hestenes, & Swackhamer (1995). Whiteboarding is central to the Modeling Method of Instruction (http://modeling.asu.edu/). The Modeling Instruction Program was recognized in 2000 by the U.S. Department of Education as one of the seven best K-12 educational technology programs out of the 134 programs evaluated. It was similarly recognized in 2001 by the U.S. Department of Education as one of two exemplary programs in K-12 Science Education.

**Why should I use whiteboarding?**

MacIsaac (2000) describes a number of reasons why teachers should considering using whiteboarding processes in the classroom. Whiteboarding can assist to increase conceptual understanding among students, foster alternative representations of knowledge, and help students practice step-by-step problem-solving strategies. There are many other reasons to use whiteboarding as well. Among them are improved classroom discourse, enhanced student learning, and increased student motivation. The quality of classroom discourse is essential in helping students develop a comprehensive understanding of the process and products of science. It allows teachers to check student understanding, and to identify, confront, and resolve student misconceptions. Whiteboarding also provides students with multiple modes and multiple opportunities to learn. Preparing and presenting whiteboard drawings can be a powerful learning opportunity for students. As they prepare whiteboards, cooperative groups necessarily discuss and come to a common understanding of what they are representing, thereby strengthening the learning process. Public presentation results in further clarification, and can be a powerful motivational tool for learning. Most students find whiteboarding to be fun. Experience has shown that students really look forward to opportunities in which they can whiteboard results of discussions, brain storming sessions, or experiments. They enjoy using a variety of colors and formats to show off their work. For many, "fun" translates to "motivation." Whiteboarding is a great way to develop an engaging, inquiry-oriented classroom atmosphere. Students who have learned using the practice of whiteboarding develop greater understanding, as has been repeatedly shown by research associated with the Modeling Method Workshop Project where Socratic dialogues are critical to the process (Hestenes, 2000).

**How does a teacher set the stage for effective whiteboard use in a classroom?**

Whiteboards are most effectively used with pedagogical practices such as showing solutions to homework sets or interpreting data from inquiry labs. More specifically, whiteboards are put to their most effective use when students are asked to employ them to demonstrate inductive or deductive reasoning processes, including debating conclusions from evidence. Using whiteboards this way, a teacher can obtain a detailed understanding of student comprehension and thinking processes. Asking students working in small groups to "whiteboard their results" takes advantage of a natural propensity of students to illustrate their data and findings. Even used once or twice, students quickly come to understand the value and meaning of whiteboarding.

**Aren't whiteboard presentations essentially the same as student reports?**

While this might at first appear to be the case, it is quite untrue. Whiteboarding involves much more than mere student reporting. Yost (2003) made a clear distinction between whiteboarding and reporting when he wrote, "Whiteboarding and reporting actually have different purposes. The report is a presentation intended to demonstrate competence, and is usually graded. Whiteboarding, on the other hand, is an active learning process in which evaluation is an ongoing process designed to probe a student's prior understanding, and to construct strategies to bring the student to a more complete comprehension." Reports are often one-way expressions; whiteboard presentations include substantial back-and-forth communication between teacher and student. In whiteboarding, other students are often asked to join in on the discussion. In the end, two essential goals of whiteboarding are to make explicit student understanding and, when necessary, expose deficiencies in student explanations (Schmitt & Lattery, 2004). Whiteboarding also ensures that students provide a complete evidence-based justification for their conclusions. This is not always the case with mere reporting.

**How should a teacher guide groups as they work?**

Teachers should manage group composition, arranging students into groups of two or three. Each group should represent a mix of ability levels; girls typically should work as pairs. Students should be assigned roles in the group activity such as leader, recorder, and critic. Student groups should be allowed to work freely on a clearly defined goal, but they should also be monitored for appropriate social behaviors that appear not to be a natural consequence of the socialization process of school. Teachers should keep an eye on student frustration levels. While learning comes from hard work, frustration can impede the process if not kept at appropriate levels. Move among the student work groups periodically asking such questions as "Why did you choose to do that?" and "What conclusions have you reached so far?" Avoid being a source of information, and avoid making prescriptive or value statements.

**How does a teacher implement oral whiteboard presentations?**

Many whiteboard presentations will begin with the teacher restating the initial problem that led to the whiteboarding presentation. The first group is allowed to make an uninterrupted presentation. This presentation might be made by one or all of the students in the group. The whole group is responsible for the content of the whiteboard presentation, and each is individually accountable for the learning associated with the process. Following the initial presentation, other students and the teacher are allowed to ask questions of the group or specific individuals. As much emphasis should be placed on the process as the product of learning. Questions posed by the teacher generally should do no more than stimulate independent thinking. Such questioning should, however, clearly help students gain an understanding that is consistent with reality. If students have made a mistake in their experimental or thinking processes, critical questioning by the teacher should help students come to this realization.

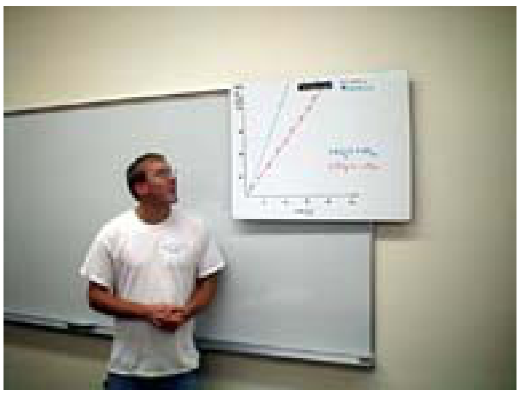
**How can a teacher minimize student anxiety?**

The anxiety sometimes associated with whiteboarding can have differing motivational effects on students. Students who know that they must make a whiteboard presentation in front of a class – explaining and defending evidence-based conclusions – can perceive whiteboarding as a positive motivator. However, if a group of students – especially a young group – is not comfortable making presentations in front of class, whiteboarding can be stressful. It proves less stressful for students to present using a circular classroom arrangement. The teacher usually moves behind the students arranged in this configuration.

**How should a teacher engage students in Socratic dialogue?**

It should be noted that the Socratic method per sé is a discussion process whereby a facilitator promotes independent, reflective, and critical thinking. The conversation that results from using the Socratic method is known as Socratic dialogue. The general goals of a Socratic dialogue are to hold students accountable for learning, make students' conceptual understanding and thinking processes clear to the teacher and other students, help all students understand how knowledge is constructed from experience, and build autonomy and self-confidence in students' own thinking in relation to a particular question that is undertaken. The teacher never badgers a student or criticizes answers. He or she merely asks students to explain their reasoning which, if flawed, can be quickly corrected by questions seeking clarification.



**What if students are hesitant to participate in Socratic dialogues?**

It is not unusual at first to encounter student resistance to Socratic dialogues. Students have often been immersed in a classroom atmosphere where they are treated as receptacles to be filled with knowledge. Socratic dialogues require students to become active pursuers of knowledge. In order for students to be more fully engaged in Socratic dialogues, teachers must address the changed classroom climate, and regularly conduct climate setting. Climate setting has two critical components – the role of the teacher and the role of the student. Students need to understand what the authentic role of the teacher is – preparing situations under which students can learn. They must understand that learning is the responsibility of students. Teachers should make clear to students that they might ask questions even if they know the answer; that they might ask "why?" two or three times in a row, and that they might ask student peers to explain and justify their conclusions on the basis of evidence. It is never wrong to seek clarification or to ask questions that deal with extensions of the problem. Teachers must point out that questioning an idea does not mean that it is wrong. Students need to understand that their role is to speak up, confront apparent fallacies, and ask questions when they don't understand. They must see the educational process as the construction of knowledge in which ideas are based on evidence, clearly stated, and clearly evaluated. They need to know that no question is "stupid," and that the only poor question is the question that is not asked. Students must assume responsibility for constructing meaning from facts that they have gathered as part of the learning process.

**What are the indispensable features of Socratic dialogue as it relates to whiteboard presentations?**

German author Dieter Krohn (Heckmann, 1981) has enunciated four essential features of Socratic dialogues. These features have been adapted here to the discussion that naturally arises about how to manage a whiteboard presentation. The four features are:

1. **Start with the concrete and remain in contact with concrete experiences.** The initial focus in the whiteboard presentation should be on what evidence students have collected. This is consistent with the fact that sciences of all sorts – social, life, and physical – are empirical. That is, conclusions are based upon observable evidence. Whiteboarding, when used in the sciences, should give precedence to facts and the conclusions drawn from them. In the end, the final question should be, are your conclusions consistent with verified facts?

2. **Ensure full understanding between participants.** Whiteboarding presentations are an opportunity for all students to learn, not just those making the presentation. All students should be held accountable for not only making and defending their own work and conclusions, but for analyzing the work and conclusions of others. All students in a classroom should be engaged in a whiteboard presentation as either presenters or critics.

3. **Adhere to a subsidiary question until it is answered.** Has an answer to each question along the way been provided? While providing an answer to the original guiding question is critical, the means by which that answer was arrived at is also critical. Have errors been made in any of the processes? Is the line of reasoning correct? Has anything been overlooked? Is the logic defensible? If at any time questions such as these arise, they must be answered before moving on.

4. **Strive for consensus.** Has the answer to both the original question and subsidiary questions been provided satisfactorily to the agreement of all who have participated in the process? If not, then it's "back to the whiteboard." Remember, no form of science – be it social, life, or physical – is the private domain of the individual. Science of all forms works upon the consensus model. Helping students arrive at a final consensus for all questions is useful in helping them understand the values of the research community.

**Please provide an example of a Socratic dialogue.**

In order to best characterize the nature of a Socratic dialogue, it will pay dividends to see negative as well as positive examples. Consider three types of questioning patterns:

1. **Initiation-Response-Feedback** (Mehan, 1979). This is the most prevalent form of interaction in the classroom. With this approach, the teacher asks a question, the student responds, and the teacher provides a counter-response. For example,

***Teacher:*** What is the equation one could use to determine the acceleration, given initial velocity, final velocity, and distance?

***Student:*** It's the difference between the final velocity squared and the initial velocity squared all divided by two times the distance.

***Teacher:*** That's correct; *v*-final squared minus *v*-initial squared divided by *2x.*

This sort of interaction does little to stimulate student thinking and provides no insight into the process by which the student chose to provide the given response. A common form of questioning that some might confuse with effective dialoguing would be the more interactive "funneling" method.

2. **Funneling** (Wood, 1998). Sometimes teachers new to Socratic dialogues will assume that the following pattern of question and response is a desirable form of Socratic dialogue. This is not so. Consider the following example:

***Teacher:*** A ball has been dropped from rest from the top of a bridge. What is the speed of the ball when it is 5 meters below the drop point?

[Long pause – no response from the students.]

***Teacher:*** Okay, let's see. What do we know about the acceleration of the ball?

***Students:*** It's 9.8 meters per second squared.

***Teacher:*** Good. Now, are we looking for an average speed or an instantaneous speed?

***Students:*** Instantaneous. We want to know the speed of the ball when it is 5 meters – no more and no less – below the point of release.

***Teacher:*** Precisely! So, how can we find the speed at this point?

[Long pause – no response from the students.]

***Teacher:*** Let's think about it. What equation can we use that relates instantaneous speed and distance? Anyone?

***Students:*** Doesn't it have something to do with the v-squared equation?

***Teacher:*** Yes, *v*-final squared minus *v*-initial squared divided by *2gx* where *g* is the acceleration and *x* is the distance.

***Students:*** So, solve for *x;* we know that acceleration equals 9.8 meters per second squared.

***Teacher:*** You've got it!

When students respond to the teacher's second question, the funneling process begins. The teacher funnels the students through a series of logical steps until they arrive at a predetermined conclusion. The teacher does the thinking, and the students only need to provide responses to simple questions. They fail to understand the underlying logic and complexity of the problem-solving process – even though they appear to have solved the problem.

A second possible interpretation of funneling is that the teacher is providing scaffolding for the students to learn the problem solving process. This is possible, assuming that students learn well by example. In the science classroom this is often not the case, because the thinking that under-girds the teacher's intellectual process is not clearly evident. Only if the teacher discusses the various questions and why (s)he asked them will it become clearly evident to students what the purpose of each question was. In such a process of modeling the problem-solving process, leading questions must gradually be removed.

3. **Focusing** (Wood, 1998). Focusing is very closely related to the process of Socratic dialogue. It consists of the teacher carefully listening to the answers of each student, and pursuing follow-up questions that make clear student

thinking. By asking leading questions, students can gently be directed to solving problems, clarifying and justifying their thinking, and learning how to problem solve during the process. Consider the following example.

***Teacher:*** A ball has been dropped from rest from the top of a bridge. What is the speed of the ball when it is 5 meters below the drop point?

[Long pause – no response from the students.]

***Teacher:*** How does one go about solving such a problem? What question do we need to address first?

***Students:*** We need to relate the given variables to the unknown.

***Teacher:*** Okay, so what are the given variables and what is the unknown?

***Students:*** We know that the ball started at rest.

***Teacher:*** So what does that tell us?

***Students:*** The initial velocity was zero.

***Teacher:*** What is the initial acceleration?

***Students:*** Zero; it's not going anywhere to start.

***Teacher:*** Hmm. How does one define acceleration?

***Students:*** It's the rate of change of velocity.

***Teacher:*** So, if the velocity isn't changing to start, how can the ball even fall?

***Students:*** Oh, yeah, it has to have a nonzero acceleration or it won't even move.

***Teacher:*** Precisely! So, what else do we know?

***Students:*** We know the distance, 5 meters.

***Teacher:*** What about the 5 meters?

***Students:*** It's the distance that the ball has fallen when we need to find the final velocity.

***Teacher:*** Is that the ball's final velocity? I mean, won't the ball keep on falling? Maybe the bridge is 15 meters high.

***Students:*** We need to know the speed right at 5 meters.

***Teacher:*** What else might we call the speed at that point?

***Students:*** Instantaneous velocity.

***Teacher:*** Good. Now, we have acceleration, initial velocity, and distance of fall. We are looking for instantaneous velocity. Do we need anything else?

***Students:*** No, we should be able to solve the problem.

***Teacher:*** And how will we do this? How are the variables related?

***Students:*** $v$-final squared minus $v$-initial squared divided by $2gx$ where $g$ is the acceleration and $x$ is the distance.

***Teacher:*** And why did you choose that equation? What's wrong with distance equals one-half $g$ $t$-squared?

***Students:*** That second equation contains an unknown, $t$-squared. We can't use that equation as a result. We need to use an equation that contains only one unknown; everything else must be known.

***Teacher:*** Excellent. So if we put all the known quantities into the first equation and solve for the single unknown, what do we get? Assume that the acceleration due to gravity is 10 meters per second squared.

***Students:*** 10 meters per second, downward.

***Teacher:*** Very good!

When the students provide answers to questions, the teacher asks for conceptual clarifications of statements or explanations of intellectual processes. The focus here is on the process of solving the problem as well as actually solving the problem itself. Process and product are equally valued. Only if the teacher focuses student attention on the process of problem solving will they come to understand how one reasons their way through such a process. Thinking is made explicit. This also helps the teacher to identify, confront, and resolve any misconceptions that students might have, and helps students learn problem solving through vicarious experiences.

**This then is the general nature of the questioning process in the Socratic dialogue?**

Generally, but not quite. Socratic dialogues so named will include both focusing and the four essential features noted by Dieter Krohn (Heckmann, 1981). The Socratic dialogue works exceptionally well with the whiteboarding process where students use inductive and/or deductive processes based on data. To see how this is done, consider the following dialogue of a group of students in front of class who are making their whiteboard presentation. They start with a brief presentation that includes reference to the notes section of Figure 1.

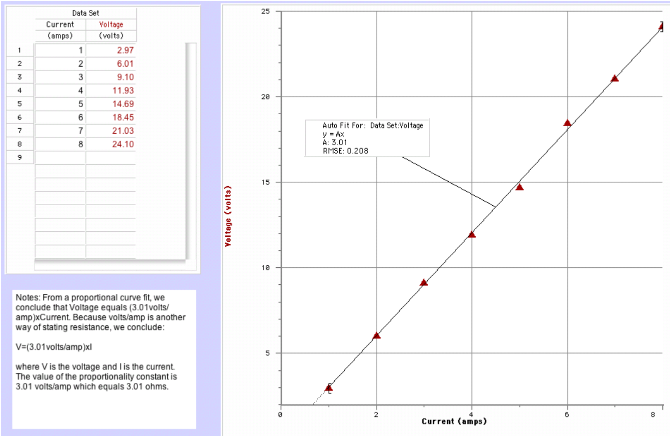



Figure 1. *Content of referenced whiteboard presentation.*

***Teacher:*** Well done. Now, can you explain to the group why you chose to use a proportional relationship ($y = mx$) rather than a linear relationship ($y = mx + b$) as the basis of your best-fit line?

***Students:*** Because if we had used a linear relationship, the $y$-intercept, $b$, would have turned out to be –0.0625 volts, and that's not possible.

***Teacher:*** What's not possible?

***Students:*** You can't have any voltage if the current is zero. Voltage in a circuit will produce current. No current, no voltage.

***Teacher:*** So how does that figure into the relationship?

***Students:*** A proportional best-fit line is most consistent with the physical situation. While a linear best-fit equation might fit the data better, the equation doesn't represent the real world. The physical interpretation is better.

***Teacher:*** So why aren't the data consistent with reality, or are they?

***Students:*** Everyone knows that there is uncertainty in every measurement, and that's what caused the scatter in the data points of the graph.

***Teacher:*** What caused the uncertainty of the data?

***Students:*** Maybe the meter isn't all that accurate, or maybe the connections were a little bit loose or oxidized or corroded. There can be a variety of reasons.

***Teacher:*** So, what does this proportional relationship tell us?

***Students:*** That voltage and current are proportional, and related by a constant.

***Teacher:*** And what is that constant?

***Students:*** 3.01 volts per amp or 3.01 ohms.

***Teacher:*** Is that true in all circumstances, or just the one you were examining?

***Students:*** No, just this one situation. The value of the resistance would be different in other circuits. Perhaps we should have said resistance instead of 3.01 ohms as the proportionality constant. That is, voltage is equal to current times resistance. That would be more general.

***Teacher:*** Okay, did other teams reach the same sort of conclusions from their data?

***Students:*** Yes, but we got different values for the slope.

***Teacher:*** And why might that be?

***Students:*** Because we had different resistance elements. The resistors look different from one another – they have different color bands. Our group got a value of 5.25 ohms for their constant of proportionality. It's because we all had a different resistors.

***Teacher:*** So, would your team agree with other teams as far as general results are concerned?

***Students:*** Yes, we basically got the same result.

Socratic dialogues might be thought of, then, as a type of focusing pattern mixed with a bit of imposed structure. Leading questions are eliminated from the Socratic dialogue because the discussion facilitator must promote independent, reflective, and critical thinking. The teacher avoids any type of funneling pattern that might supplant student thinking. Remember, the general goals of a Socratic dialogue are to hold students accountable for learning, make students' conceptual understanding and thinking processes clear to the teacher, help students understand how knowledge is constructed from experience, and build autonomy and self-confidence in students' own thinking in relation to a particular question that is undertaken in common.

**Should whiteboard presentations be scored or graded?**

Whiteboarding is part of the learning process. It would be unreasonable to grade the performance of a young violinist who is just learning how to play. Students just learning to play naturally make many mistakes; it's part of the learning process. The goal of whiteboarding is not student reporting; rather, it used by teachers to assess (not evaluate) and help improve student understanding. Teachers should feel free to grade a final performance, but not the learning process. Hence, it is not usually advisable to score or grade the whiteboarding process itself.

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