# A Scientist's Guide to Making Successful Presentations to High School Students

## How to Leave Them Asking Questions and Wanting More

*By*

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# Chapter 1

## Passing on the Torch

Three compelling reasons for scientists to become involved in science education.

**I. Science and Technology Give Us Our High Standard of Living.**

Our nation depends on the quality of our scientists and engineers to maintain our place in the competitive global scientific community. It is indeed a tragedy that the number of young people selecting science and engineering careers has not increased during a generation in which science and technology pervades every aspect of our lives. A variety of reasons, such as the uninteresting curricula in grades K-12 and teachers who are inadequately trained and poorly rewarded, have been given to explain this phenomenon. Some steps to remedy these problems are being taken, but your help is needed to solve this problem before the predicted shortage impacts on our society, economy, quality of life, and survival. You, as a trained scientist, can make a difference by personally making contact with young people. You can share your values, motivation, and expertise with students who are still willing to listen. You can make a difference.

You can promote a general understanding of the importance of science and its impact on our standard of living. You can help students develop an awareness of science. You cannot do this from your lab or through comfortable, impersonal lectures. But as a scientist who would like to share a method of solving problems that results in cumulative successes, you can help capable young students choose a career in science.

**II. Our National Educational System Is in Crisis. We Are No Longer Competitive Internationally.**

Though most Americans are not scientifically literate, international studies of educational performance indicate that U.S. students rank near the bottom in achievement in science and mathematics. A study of National Assessment of Educational Progress has found that despite some small recent gains, the average performance of 17-year-olds in 1986 remained substantially lower than in 1969. A look at our educational system reveals some of the reasons for this situation. Few elementary teachers have even a rudimentary education in science and mathematics, and many junior and senior high school teachers of science and mathematics do not meet reasonable standards of preparation in those fields. It is the system, not the teachers, that is to blame for this state of affairs. Science and mathematics teachers have not been provided the opportunities needed to keep up with recent technological developments. Textbooks and methods of instruction often impede progress toward scientific literacy. They emphasize the learning of answers more than the exploration of questions, memorization rather than critical thinking, and reading instead of experimentation. This passive exposure to science is not enough to entice students to pursue careers in science.

**III. Share the Excitement of Scientific Discovery.**

You can communicate the true nature of science, the excitement of the pursuit of the "truth," the durability of knowledge, and the evolution of thought. You can convey the excitement of discovery that a scientist experiences. You can help students understand that the norm of science is to modify ideas in the light of new knowledge; that powerful constructs tend to survive, grow more precise, and become widely accepted. Only the scientist can help the students understand that experiments that do not go well are not failures, but just the next step on a new path.

The best way to communicate the characteristics of scientific inquiry is through examples from your research:

- Science demands evidence
- Science is a blend of logic and imagination
- Science explains and predicts
- Scientists identify and avoid bias
- Science is not authoritarian
- Accepted ethical principles generally govern the scientist

You can make a difference. Come and experience the rewards of stimulating the minds of our youth and opening the door for them to a career in science.

The most important contribution that a scientist can make in the classroom is the modeling of the real scientific research skills of investigation, critical thinking, imagination, intuition, playfulness, and thinking on your feet and using your hands. Some of the most exciting lessons are in content areas outside of the scientist's expertise, such as investigating a problem to which no one has an answer. The excitement of science can best be conveyed to students by involving them in investigation that is open-ended, inquiry-based, and student-driven.

# Guidelines for Great Presentations

## Don't Lecture—Engage!

Share the personal dimension of your scientific research work. As with any subject, it is important for students to feel a sense of personal involvement with science. As a working scientist, if you communicate your own feelings and emotional involvement in your work, and if you present the more technical content in this context, you will help motivate students to study science.

Let students know that they are important; acknowledge the significance of their own study and questions. Students learn more when they are treated with integrity, sincerity and openness. They will learn more science through positive interpersonal rapport between the scientist and student. One important finding in regard to helping others is that aloofness has a negative correlation with effectiveness. If students are treated as objects, the relationship becomes impersonal.

Effective communication is the idea that covers most of the important aspects of personalizing science. Take time to talk to the students. You must reciprocate by listening to the students and discussing topics that interest them. Listening unhurriedly, responsively, and empathetically will enhance your personal image with students. The message, "I care" comes through and it is always well received.

## Discovery Promotes Confidence

When presenting a problem to students, try to provide opportunities for the students to solve it themselves. Your role may include questioning, assisting, giving clues or hints at possible solutions, and suggesting new directions for solving the problem. The discovery process is an excellent motivator because it promotes a sense of self-confidence and confidence supports risk taking.

## Success Motivates

Few things motivate students like success. To use success as a motivator, design activities where students will have to expend an effort in an uncertain situation. The activity must be challenging, but not beyond achievement. The potential for success quickly becomes frustration when success is not achievable.

## Feedback Reinforces Learning

The amount, specificity and immediacy of feedback are critical in improving student motivation. Make the feedback specific like "your pipetting techniques are excellent," or "your question about the reliability of my data is an important factor to consider." Show the students respect for their abilities and concerns.

Feedback can be in the form of question and answer, which is prepared. Questions may be planned before class or may arise spontaneously because of student interaction. Before you devise your questions consider the following:

## Keep Student Interest

Utilize the students' interest in themselves. Almost any lesson can be related to some facet of students' lives. Use such simple attention getting techniques as changing your voice or position in the room. Keep variety in the talk.

1. What talents are you going to try to develop? (Mathematical, problem solving, etc.)
2. What critical thinking processes will you try to nurture? (Analysis of concepts from more than a single source.)
3. What subject matter objectives do you want to develop? (Relate the talk to the content of the course if possible.)
4. What types of answers will you accept? (Tell the students if you wish them to include an example or explanation in their answers.)
5. What skills do you wish to develop? (Laboratory skills may need some practice before implementation.)
6. What attitudes and values do you wish to emphasize? (Ethical or practical applications of research knowledge.)

## Wait-Time Affects the Quality of Responses

When instructors wait three to five seconds before responding, the following occurs:

1. Students give longer and more complete answers instead of short phrases.
2. There is an increase in speculative, creative thinking.
3. "Shy" students increase their participation.
4. Instructors become more flexible in their responses to students.
5. The number of suggested questions and experiments increases.
6. Instructors ask fewer questions, but the ones they ask require more reflection.
7. Students give a greater number of qualified inferences.
8. Instructors' expectations for student performance change: Instructors are less likely to expect only the brighter students to reply.

## Role Modeling

To function as a role model the speaker may include a short resume of academic preparation and career experiences. Making use of scientific knowledge and techniques will add credibility.

## Closure

Students should be encouraged to summarize skills, knowledge and understanding of the presentation at the conclusion of the experience. Important points include:

- Encourage the students to summarize the knowledge, skills, and attitudes they assimilated from the presentation.
- Relate objectives of the talk to concepts they have learned previously.
- Communicate a sense of appreciation for student involvement in your presentation.

## Tele-Mentoring over the Net

Educational mentoring can be conducted with ease worldwide using the Internet. This enables you to help students or teachers via e-mail, or via audio or video conferencing. When a good match is found, the effects can be powerful. You may mentor an individual or a class of students. You might want to volunteer your services as a subject expert to a particular school and teacher. You should telephone the school and ask to speak to a biology teacher. Tell the teacher what you are willing to do with regard to topics, response time, and the number of questions you will entertain within a given period. You might also consider working as a role model in science with an individual or group of students interested in a career in the field.

# Bring Your Presentation to Life

Students succeed in learning content by becoming involved in the process.

## Discussion Versus Lecture

Students become more interested because they are involved. The objective of modern science instruction is to teach science as a process with emphasis on the cognitive development of the individual, students must have the opportunity to think. A lecture is passive learning with little thinking required, just staying awake. Students are often thrilled to discover fundamental ideas for themselves and not simply be told.

Tips for a good discussion:

1. The speaker should present an interesting background analysis before eliciting comments for the participants.
2. Discussion may be initiated by a model, object observation, demonstration, or audio-visual display.
3. A discussion may center on a case history and branch out into what needs to be known to treat the patient, understand the problem, or find a common characteristic from many examples.
4. Relax the audience; use humor to reduce tension.
5. Avoid embarrassing anyone.
6. Keep the discussion moving at the students' pace, which can be ascertained by the number and complexity of questions they ask.
7. Rephrase any comments that might be misunderstood, such as the misuse of scientific terms.
8. Be aware of anyone monopolizing the discussion or going off on a tangent.
9. Ask a variety of questions that draw on different levels of thought.

## Demonstration

Demonstration can be used for many reasons: lower cost, availability of equipment, economy of time, less hazard from dangerous materials, direction of the thinking process, or to show the use of equipment.

1. Make all activities easily visible.
2. Show personal excitement over the event that is taking place.
3. Involve the students in making observations, suggestions, predictions, evaluations, and in assisting.
4. Start the demonstration with a question; teach inductively.
5. Ask questions constantly.
6. Use the blackboard to reinforce, illustrate, or collect data during the demonstration.
7. Verify that objectives are clear and that conclusions relate to those objectives.

8. At the conclusion of the demonstration, have a student summarize what has occurred and why.
9. Expand the questions to the broader philosophical basis of science. For example, you may ask:

   - How certain are we of our data?
   - What evidence is there of certainty in science?
   - How do scientists fractionate knowledge to find answers to bigger problems?
   - Are there social implications of the concepts presented?

Students directly relate effectiveness of the laboratory experience to the amount of individual participation. The ideal arrangement would be to have each student wholly responsible for conducting the experiment from start to finish. This would include the preliminary planning, gathering materials, preparation of apparatus, designing the method, collecting data, analyzing results, and drawing conclusions. Such an ideal situation would insure that the work of the individual student could be evaluated and that every student would have a maximum learning experience.

If the facilities available or the time allotted do not allow for individual work, teams may be formed to accomplish the task. Different activities may be assigned to each team or all teams may work on the same task and the data can be compared and evaluated together. Provide a clear structure and work assignments. Teachers may assist in assigning laboratory chiefs, or group selection. Laboratory chiefs or team leaders can collect or pool data and facilitate all team activities. The atmosphere should be as realistic and professional as possible. This may include safety procedures, solution preparation, and storage of materials, and keeping accurate data books. Laboratory activities should foster teamwork, skill development, and a reinforcement of theory in its application. The process of discovery can be exciting and rewarding for students when accomplished in an atmosphere of safe risk taking. A scientist provides expert guidance to foster appropriate experimentation.

# Prepare and Know Your Audience

By knowing what the students have been exposed to, the scientist can make his presentation understandable and yet stimulating and challenging.
What can I expect a student to know?

What skills will the students possess?

**What You Should Know Before Entering the Classroom:**

1. Type of class, e.g., Biology, Anatomy
2. Level of class, e.g., advanced, average
3. Grade range of students, e.g. 10th or 10-12
4. Time you will have for presentation 30-90 minutes
5. Size of audience

6. Equipment available for audiovisuals
7. Laboratory facilities available
8. Students' preparation for presentation
    a. Articles sent ahead and distributed beforehand
    b. Discussion of current related topics
    c. Basic skills necessary for activity
9. Possible follow-up activities
10. If students will be held accountable for information in the presentation
11. Evaluation of presentation for feedback

**Following Is a List of Curriculum Topics Covered in Selected High School Science Courses.**

## Science Curriculum

**Biology A**
(9-10 grade students)
The first semester usually includes study of cell biology, reproduction, genetics, evolution, and plant and animal classifications. Students should be able to:

1. Use methods of qualitative and quantitative observation.
2. Describe the general structures, functions, biochemistry and diversity of cells.
3. Describe levels of organization.
4. Explain perpetuation of species.
5. Apply laws of classical genetics and the principles of chromosomal inheritance to problems of genetic differences in individuals.
6. Explain the general functions of DNA and RNA.
7. Compare scientific theories of the origin and evolution of living things.
8. Apply methods of taxonomy to classify organism.
9. Identify career opportunities in the biological area.

**Biology B**
The study of ecology, behavior, and human structure and function are covered. Students should be able to:

1. Describe the characteristics of micro-organisms.
2. Describe general anatomy and physiology of plant and animals.
3. Explain the biological behavior of living things.
4. Understand the relationships in energy flow patterns, and the development of the ecosystem.
5. Analyze the skills required for the practice of biotechnology.

(11-12 grade students)
Students usually have had an introductory course in chemistry and biology. Students should be able to:

1. Explain the phenomena of free energy change and entropy.

2. Trace the history of cytology.
3. Relate the C3, C4, and CAM pathway to plant anatomy, photosynthesis and the environment.
4. Describe the models for gene regulation.
5. Understand genetic abnormalities with emphasis on chromosomal aberrations.
6. Discuss the structure, physiology, reproduction, pathology and economic importance of viruses and Monerans.
7. Trace various immunological responses.
8. Relate the Hardy -Weinberg law, genetic drift, and balanced poly-morphism to evolutionary situations.
9. Interpret current issues in biology, including population growth, ecological intervention, and biomedical progress.

**Anatomy and Physiology**
This course is intended for students who have had general biology and may have had chemistry. Students study cells, their sub-microscopic parts and how their structure relates to function. They study the major organ systems of the human body: skeletal, muscular, nervous, and digestive system.

**Chemistry A**
Chemistry A topics include the organization and classification of matter, atomic theory, radioactivity, the periodic table of the elements, principles of chemical reactions, heat, molecular motion, and chemical bonds. Students should be able to:

1. Differentiate among elements, compounds, and mixtures, using physical and chemical properties.
2. Distinguish among physical, chemical, and nuclear changes.
3. Select and use mathematical relationships and computational skills.
4. Perform laboratory skills appropriate to chemistry.
5. Use chemical symbols to write formulas and name compounds.
6. Describe the sequence of selected discoveries, which resulted in modern atomic theory.
7. Predict physical and chemical properties based on the periodicity of the elements.
8. Imply the mole concept operationally and conceptually.
9. Construct chemical equations.
10. Solve problems involving quantitative relationships in equations.
11. Relate the state and energy content of a substance to the degree of motion in its molecules.
12. Apply the gas laws.
13. Account for the attractions among particles and the effect of these forces on the properties of the resulting substances.

**Chemistry B**
Chemistry B topics include energy, chemical reactions, equilibrium reactions, chemical solutions, acids, bases, salts, electrochemistry, and carbon and its compounds. Students should be able to:

1. Determine the amount of energy involved in a reaction.
2. Determine the driving forces of a reaction.
3. Interpret the practical implications of the laws of thermodynamics.
4. Describe the factors that affect the rates of reactions.

5. Describe systems of equilibrium.
6. Calculate the quantities needed to prepare and use solutions employing various units for expressing concentrations.
7. Analyze factors that determine the properties of solutions.
8. Identify reactions involving ions in aqueous solutions.
9. Analyze the role of acids, bases and salts and their interactions.
10. Apply electrochemical principles.
11. Balance oxidation-reduction equations.
12. Apply principles of oxidation and reduction.
13. Classify carbon compounds.
14. Illustrate the significance of carbon and its compounds.

**Physics A**

This course treats vector analysis, the study of motion (kinematics), the effect of force on moving bodies (dynamics), energy, and momentum. Student should be able to:

1. Apply vectors to the solution of physics problems.
2. Analyze rectilinear motion.
3. Analyze curvilinear motion.
4. Apply Newton's laws of motions.
5. Develop the law of universal gravitation.
6. Apply the law of conservation of mass-energy.
7. Apply the law of conservation of momentum to the interaction of objects.

**Physics B**

Physics B covers the topics of thermodynamics—the effect of heat on motion, electricity, magnetism, wave motion, and modern physics. Student should be able to:

1. Solve problems of thermodynamics.
2. Describe the phenomena related to electrostatic charge.
3. Apply Coulomb's law.
4. Apply principles of electrostatic potential and potential difference.
5. Solve problems involving electrical circuits.
6. Solve problems involving magnetism.
7. Analyze the behavior of waves.
8. Describe models of the atom.
9. Describe the dual nature of light and matter.

If there is a particular topic the scientist would like the students to be aware of, the teacher can be notified. Pertinent pamphlets, handouts, a film (if available), or other preparation can be provided several days before the presentation.

## Teacher Critique of the Presentation

*(Feedback from presentations may be gathered on forms such as these. The speaker will be sent an evaluation as a guide for future presentations.)*

Please evaluate the presentation. Use 1 as inappropriate to 5 as excellent.

| | | | | | |
|---|---|---|---|---|---|
| Enthusiasm of speaker | 1 | 2 | 3 | 4 | 5 |
| Voice quality and articulation | 1 | 2 | 3 | 4 | 5 |
| Adaptability and flexibility | 1 | 2 | 3 | 4 | 5 |
| Appropriate Use of English | 1 | 2 | 3 | 4 | 5 |
| Organized procedure | 1 | 2 | 3 | 4 | 5 |
| Adequate summary | 1 | 2 | 3 | 4 | 5 |
| Appropriate content level | 1 | 2 | 3 | 4 | 5 |

Comments:

1. What are the strengths of the presentation?

2. What were the weaknesses of the presentation?

3. What would you change in the presentation?

4. Would you have the presenter again next year?

Signature of teacher evaluator:____________________

## Student Critique of the Presentation

*(Students in the class may receive this type of form to help the speaker improve future presentations.)*

Please evaluate the presentation. Use 1 as inappropriate to 4 as excellent.

| | | | | | |
|---|---|---|---|---|---|
| Enthusiasm of speaker | 1 | 2 | 3 | 4 | 5 |
| Vocabulary level appropriate for audience | 1 | 2 | 3 | 4 | 5 |
| Interesting content | 1 | 2 | 3 | 4 | 5 |
| Warmth of personality of the presenter | 1 | 2 | 3 | 4 | 5 |
| New ideas presented | 1 | 2 | 3 | 4 | 5 |
| Talk was easy enough to follow | 1 | 2 | 3 | 4 | 5 |

Comments:

1. What new information did you learn from the presentation?

2. What was the most important concept presented by the speaker?

3. Have you become aware of a new potential career for yourself?

4. What further questions do you have that the presenter might be able to answer?

**Student information:**
Age: _________________
Grade level: _____________
Gender: ___________ _____
Course: _________________

**Speaker: ___________**
Teacher: ______________
School: ______________
Date: ________________
Topic: ________________

## References

**Books:**
Trowbridge, L. & Bybee, R. W. (1986). Becoming a Secondary School Science Teacher (4th ed.). Columbus: Merrill Publishing Co.

**Reports:**
American Association for the Advancement of Science. (1989). Science for All Americans, a Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology. Washington, D.C.

**Periodicals:**
Attkinson, R. C. (1990). Supply and Demand for Scientists and Engineers: A National Crisis in the Making. Association Affairs, 248. 425-432.

Holden C.. (1989). Wanted: 675,000 Future Scientists and Engineers. News & Comment, 244. 1536-1538.

Pool R.. (1990). Who Will Do Science in the 1990s? Science: News & Comment, 248. 433-435.

**Internet source:**
http://www.nas.edu/rise/backg2a.htm
Bower, James M. "Scientists and Science Education Reform: Myths, Methods, and Madness." National Academy of Sciences, Washington, D.C., 2002.

http://www.gse.uci.edu/CCRE/telelearning/tmentor.html
Riel, Margaret. (1999) "Tele-Mentoring over the Net: The real power of the Internet is the energy generated by human interaction."

# Chapter Two

## Understand Your Role in Science Education

### Your knowledge, expertise, and experience can bring life to high school science.

#### Your Place in the Classroom

What can you do as a scientist that a science teacher can't or does not do? You can bring a systematic approach from your experience in the laboratory.

- Make the science come alive by illustrating how classroom science applies to the professional laboratory.
- Make the students aware of the relevance of science to their lives.
- Make students believe that their knowledge of science can make a difference.

In most science courses, teaching is done by explaining relevant scientific topics, giving examples, and providing practice: The presumption is that such instruction is sufficient to make students capable of using their newly acquired knowledge effectively. Sometimes special environments such as laboratories or computational environments are provided, where students can explore and learn by discovery. There is a presumption that the students will acquire useful knowledge and even transfer their learning to other domains. There is evidence today that the learning outcomes are often disappointing. Students need help in making the jump from theory to application. You can provide this help by giving them more experience in the procedures and processes of science.

#### Scientist/Educator Partnerships

Students benefit most by scientist/teacher partnerships because teachers gain content knowledge and insights into the process of scientific investigation. The scientists also gain from this relationship because they become more sensitive to the needs of teachers. They form a team by merging the experience of teaching strategies and content knowledge. This team approach is most effective when working with middle or high schools students. Most science teachers have had little experience working as practicing scientists, yet their students look to them as content "experts." Both parties should have a mutual respect for their partner's expertise. A partnership can quickly dissolve if either party dismisses the professional experience of the other.

The scientist can benefit from the partnership by spending time in the classroom and perhaps thus gaining an appreciation for diverse pre-college teaching methodologies and strategies. It is important to understand that student learn at different rates and in different ways. The depth of knowledge that a scientist possesses on a particular subject may be a liability because the students need to know only what is necessary to perform an experiment or to understand a concept. Too much information may cause confusion. Both the scientist and teacher may need to make concessions to preserve the scientific integrity as well as the pedagogical integrity of the experience for the students.

## Processes of Science

Students think of science as “hard,” ”cold” and isolated from humanity. We need help in dispelling these ideas. You can make a difference by your interest in improving science education through personal contact with students. Science material appears “hard” because of the unfamiliar vocabulary and symbols, and perceived higher level thinking processes necessary to comprehend the concepts. There appears to be a need for a systematic approach to learning written scientific material. One systematic approach to the comprehension of complex reading material is to follow a series of steps to extract meaning from the scientific content.

- Ask questions about the reading material.
- Seek to clarify what has been read.
- Summarize and organize the information with the students.
- Allow students to make predictions to test understanding.

A more systematically designed and explicit instruction is often needed to help students learn scientific knowledge that they can use reliably and flexibly. This means that information needs to be analyzed in adequate detail to ensure that the student learns the desired kinds of knowledge and thought processes.

Small group activities provide important opportunities to develop problem-solving skills and concepts in ways that are not possible in most large groups or even in individual instruction. A small group in a science class can wrestle with ways to solve a problem or brainstorm, share, and evaluate competing ideas. The data, real or simulated, can be presented to a class, shared and discussed in small groups. The group can collaborate in interpreting the data and in raising questions about inferences, errors in measurement, meanings, and applications. The post-lab discussions can assist in developing understanding and problem-solving skills.

A class may be divided into smaller groups to accommodate task sharing. An investigation itself can be broken into component tasks to be shared by different members within these groups. This task sharing can enable a science class to address more complex and realistic problems that may enhance the relevance of school science. Relevant material helps attract and retain students in science. Learning the scientific method provides students with useful tools for life.

One such tool is systematic problem solving. Most students find this difficult, however. To overcome such difficulties, one needs to identify and then describe clearly a general problem-solving method. Consider the following:

1. Determine initial problem description.
2. Consider a method or procedure of attack.
3. Consider the assumptions.
4. List possible solutions.

5. Determine the most appropriate solution.
6. Consider the limits of applications.
7. Predict extensions of investigations.

These steps help the student design a solution. Instructors should ask more provocative questions and tantalize the students with unexplained demonstrations to encourage this process. Both patience and persistence are main ingredients in the search for the solution.

With the transition into the information age, science will be increasingly encountered in everyday life. Students must be exposed to basic scientific principles and laws, which will help them to understand the issues of human survival. They must experience the process of science that will help them learn how to make science related choices and decisions. The dynamic nature of science must become increasingly evident. The students need to understand that the constant growth of science effects change in other fields.

This can be illustrated by the integration of science and other disciplines. Science education must also combine exposure with inquiry to prepare students to respond intelligently to the explosion of scientific information that they are exposed to daily. Students must understand that true science is rather like a treasure hunt because the scientist does not always know what will be found or when it will happen. The process is both exciting and frustrating.

## Gain Public Trust through Understanding

People have a paradoxical attitude toward science. They are put off by what they perceive as the know-it-all attitude of scientists and their impersonal delivery of information, and yet insist that scientists solve every problem that exists. Most people believe that with enough money and effort all problems can and will be solved.

Scientists must gain the trust of the public by generating a clear understanding of the processes of science. Mistrust evolves from the public lack of understanding. For example, the public asks the question: Why is AIDS so hard to cure? The answer is not as simple as the question.

The public has lived through the cure for polio and therefore believes that science should be able to cure AIDS. Viruses cause both diseases. They do not realize that the HIV virus is more difficult to stop than the polio virus. The public does not understand that HIV is difficult to stop because it can mutate in a matter of hours, whereas other organisms mutate over a period of years.

This is an example of the misunderstanding of the process and nature of science. It is this process that the scientist can best address. Using examples that are in the public eye can make high school science courses relevant. An emphasis on the process of investigation will help students transfer their knowledge to other situations as the need arises.

Beyond the Classroom:

There are many ways that you can contribute to improving science education.

- Invite science teachers to participate in special lectures, demonstration programs, or tours.

- Interact with science educators
- Distribute materials, such as information, brochures, reports, surplus journals, books, or equipment from laboratories and professional organizations, to science teachers in local school systems.
- Participate in programs developed by science educators to upgrade science education for students in general and the gifted, in particular.
- Get involved in efforts to raise public awareness of the role of science and mathematics in contemporary society.
- Encourage involvement and provide recognition for colleagues and employees who become involved in efforts to enhance primary and secondary school science programs.
- Volunteer as a:

  Speaker in a visiting scientist program or a speaker's bureau

  Advisor to teachers, boards of directors of educational programs, teacher preparation committees, or students.

  Workshop participant in short courses, training sessions, part of an academic course, or curriculum development.

  Worker in efforts to inventory surplus supplies, or equipment to be loaned or given to local schools.

## Plan the Process

Research has identified factors that influence students in selecting courses in mathematics and science, particularly among young women and members of minority groups. In addition to achievement in previous educational experiences, individuals are more likely to continue their mathematics and science education if they have general interest in "things," rather than primarily in "people." Students need exposure to "things," that is: they need to manipulate objects in the laboratory or classroom if they have not had that experience at home. It is this experience that gives them the self-confidence to succeed in the sciences.

You can be the resource that brings students in contact with objects of science either by relating experiences to them or by arranging to bring items directly into the classroom for the students to handle.

## Leave an Impression

People learn through involvement. Learning is not passive in nature. People do not learn from words; they learn from experiences that pay off. Therefore, opportunities should be provided for the person to be actively involved in the learning process. If learning is to be retained, one must have an opportunity to repeat what has been learned. There have been many different studies on how much a person retains after a learning activity. Although the results may vary slightly from one study to another, they are always startling. The general loss, which occurs in one hour, is about 55 percent of information learned and in one week the loss increases to 75 percent. As a result, if learning is to be effective, it must be put to use. Any information that you wish the student to retain should have a mental, physical, or emotional activity attached to the learning process. Keep this in mind when preparing the lesson to be learned and remembered.

People learn in small doses; therefore, presenting information in simple steps in sequence allows students to absorb information in small bites. Observe changes in thinking and behavior, to evaluate your success in reaching your intended audience.

- Learning should move from the easy to the more difficult. The subject matter covered ought to move from the known to the unknown. People need to see some connections between the old and the new, the familiar and the unfamiliar.
- Learning should start slowly at first and build momentum as the learner experiences success in the activity.
- Learning should involve all of the senses. It has been established that 80 percent of what we know has been picked up through our eyes. Consequently, visual, and audio aids help the learning process.

## Reach the Intended Audience

Your subject matter must be presented at a level the students can understand. It must appeal to the gender and makeup of the audience and be sensitive to the multicultural background of the students to maintain their interest.

**Readability Level:**

The reading level of written material to be presented to students must be at an appropriate level of difficulty. The reading material can also be used to evaluate the level of vocabulary for an oral presentation.

To test written material for the level of vocabulary, take three 100-word samples from the beginning, middle, and end of the printed material. Count the number of sentences and divide into 100. Count the number of words that have 3 syllables or more and add that number to the above. Multiple that number by .4 to get the vocabulary grade level of the material.

Example

*Geneticists study all aspects of genes. The study of the modes of gene transmission from generation to generation is broadly called transmission genetics, the study of gene structure and function is called molecular genetics, and the study of gene behavior in populations is called population genetics. These form the three major subdivisions of the field of genetics, although, as with all categories invented by humans, the subdivisions are to a certain extent arbitrary and there is considerable overlap. It is the knowledge of how genes act and how they are transmitted down through the generations that has unified biology; previously, specific sets of biological phenomena had each been regulated to separate disciplines.*

In this sample you can see that there are only four sentences in the 100-word passage and 26 words with three syllables or more. (100 ÷ 4 = 25; 25 + 26 = 51; 51 x .4 = 20.4) this calculates to be above college level. The thing to remember when preparing either written or oral material is to keep the sentence structure simple and the three syllable words to a minimum.

## Have the Goals of the Interaction Clearly in Mind.

What the learner should:

1. Know (i.e., information, facts, principles)
2. Apply from the knowledge gained (i.e., work habits, or skills)
3. Develop or change about her/his attitude (i.e., feelings about things and people)

These goals should be reachable in the time allowed.

## Foster Equity in the Classroom

There are still barriers to the entry of women into science, including the absence of women from textbooks and widespread publicity about supposed female inferiority in the cognitive abilities, such as spatial visualization and the mathematics needed for science. Some feminists criticize science as too "masculine," implying that women will not be successful until science itself changes its character.

Some of this problem can be remedied by giving credit to the contributions of females in textbooks, by providing course coverage of these accomplishments and by inviting guest speakers who emphasize women in science and encourage girls to enter the field of science by suggesting career opportunities. Scientific institutions can provide females a positive experience in a laboratory to learn skills and techniques. This can expose them to learning scientific concepts that will give them the confidence that they need. By providing a safe atmosphere for risk taking with a supportive mentor, the females will experience a feeling of success and greater confidence in their abilities. That feeling is what allows an individual to take risks or be creative. The risk taker knows that if she fails there will be someone there to catch her.

Recent psychological studies on cognitive sex differences have shown that these differences are much smaller than usually assumed. A spatial advantage for males increases after puberty and persists through adulthood despite no consistent sign of sex differences in general intelligence. According to recent research, sex differences in cognition result from socioculturally determined sex role pressure. Boys, but not girls, are encouraged to perform spatial tasks such as block building. This may be the reason that they develop more advanced spatial skills.

From earliest childhood, girls are not encouraged to find out how their toys work by taking them apart, thus losing a valuable opportunity to develop mechanical inquisitiveness and skills. By third grade, girls are conditioned to accept toys as they are and not to manipulate or change them. By fifth grade, they are quite reluctant to work with science toys, explaining that, "I'm a girl; I'm not supposed to know anything about things like that." Boys tend to play with action-oriented toys and learn many mathematical and scientific concepts. Girls experience play patterns that are stationary, stimulating little interest in understanding natural laws that govern the physical world. There appears to be no scientific basis for the assumption that a much larger number of women cannot be successful scientists because of innate mental limitations. It appears to be biased socialization.

The recent report "How Schools Shortchange Girls" states that there still is little encouragement for girls to pursue math and science, few female role models in textbooks, and subtle teacher practices favoring boys, such as calling on boys more often or gearing school and play activities more to the males. There may be a disparity between males and females in standardized math and science tests. Teachers often steer more boys then girls to scientific fields. Males still outscore females on SAT 498 to 455. On the 1988 SAT, the gap in science was wider. On the achievement test in physics, males averaged a 611 score out of 800, 56 points higher than females average score of 555. The fact that girls often have better grades in high school than boys, leads researchers to suggest bias in the tests. These tests determine college admittance and scholarships.

Several studies have suggested that girls are further disadvantaged because teachers encourage male students to work with laboratory equipment, especially in the more complex sciences. Girls are criticized for lack of effort or the failure to be neat and precise which lowers their self-esteem and reduces their incentive to take risks.

## University Studies Reveal

David Sadker of the American University suggests that researchers move around the room to avoid calling on more boys than girls. He also encourages speakers to use inclusive or generic terms; avoid masculine pronouns such as he or his or gender sensitive terms like mankind.

Carolyn Callahan of the University of Virginia has explored the philosophy behind the lower level of interest among girls in the fields of science and mathematics. Girls tend to view science as negative; responsible for pollution, nuclear warfare, depleting the ozone, and carcinogens. It is important, then, to tie science into socially positive causes like curing disease, alleviating famine, and creating high-tech prosthetics. The social image of the scientist is also less than ideal. Often the scientist is equated with some genius hermit locked in a laboratory without social contact. This stereotypical scientist is elitist, has his own sense of humor, understands only inside jokes, speaks a language almost unintelligible to the common person, and is always male. To unseat this stereotype, presentations to high school students should include references to teamwork among scientists and collaborations on various projects, including mention of female scientists and the significance of their work. The presenter should be careful to use language that is easily understandable and free of jargon that would exclude parts of the audience.

## Support for Females

The courses students take in secondary school influence and limit subsequent college and career choices. Most girls do not elect to take advanced science and mathematics classes even if they do well in those subjects. Although there is little difference in the ability of males and females to do mathematics, there is an enormous gap in the numbers of boys versus girls that study mathematics. Lacking four years of college preparatory math, young women find themselves eliminated from many college majors, including astronomy, civil engineering, biochemistry, physics, mathematics, medicine, forestry, economics, and computer science. They generally find themselves in education, social work, nursing, and the humanities--fields that offer much in the way of social worth, but comparatively less pay.

## Patience for Males

Boys do not like math better than girls. The greater participation by males in math is related to the males' understanding that math may be a necessary prerequisite for their subsequent careers.

The differential treatment of males and females in schools is bad for both sexes. The pressure on men to compete and succeed may result in frustration and stress. Many men work constantly to build and preserve their "masculinity." Society has given them the superman fixation which may involve sexual virility, bravery, risk taking, physical strength, skill in sports, aggressiveness, exercise of power, control, and dominance. This is an impossible task and leads to frustration in not being able to meet these expectations. These males may become maladjusted, underachievers, truant, delinquent, inattentive and rebellious. Their traits of tenderness, sensitivity, and emotion may be under-developed. Unrestrained aggressive behavior causes serious problems in schools and in society.

## Multicultural Background

Minorities, women, and other disadvantaged groups have not traditionally excelled in the areas of science, mathematics and computer technology.

Individual methods of processing information and problem solving vary greatly. Research has shown that minorities and women learn in similar ways, but in a way different from that defined by educators as the norm. There are many factors that play in this difference:

Students whose family life is in turmoil suffer the effects of stress in several ways. Parents who are under pressure are severely hampered in their ability to help their children with schoolwork. Students themselves internalize family stress, and it damages their self-esteem and therefore their ability to learn.

Students whose first language is not English or is a nonstandard English dialect may have difficulty in understanding not only the words used but also the cultural context of the material.

Acceptable behavior differs among cultures. Take the case of Native American children who may never have been singled out for praise or censure and may have been expected to be silent in the presence of powerful adults These children may not be comfortable responding to a teacher's individual attention and may consequently find learning in school difficult.

Females have been discouraged from pursuing careers in science and mathematics because it is considered not as "feminine". In minority families, parents' negative or outdated attitudes can suppress girls' ambitions for a career in technology. Most female students lose their interest in mathematics and science as a result of social pressure and an earlier lack of achievement in these areas.

## Learning Styles of African-American Children

The differences between the cognitive functioning and learning styles of African-American and Caucasian children are simply differences and not deficits. African-American learners prefer experimentation, improvisation, and harmonious interaction with others and the environment. Cooperation is an important dimension in the learning style of African-American children. Research has found that cooperative learning groups, in which small, heterogeneous ability groups work together on learning tasks and activities, are particularly effective for African-American students. When instruction techniques involve more stimulus variety, greater verve, and rhythmic, verbal interactions, the African-American students performed better than they did with traditional techniques.

## Promote Achievement in School

Successful programs are high quality and long-term. They start early and continue throughout the schooling of targeted groups. The emphasis in science and mathematics programs should be on enrichment rather than on remediation and should allow students the opportunity for hands-on experience. Programs should be enhanced through enlistment of universities, businesses, and the community in cooperative efforts. The enrichment process includes the understanding of the material presented as it relates to the students' lives and learning styles. You will be successful if you :

1. Present material in the context of students' lives. Embed the information to be taught and the problems to be solved in a context familiar to the students. Once students realize how they can make immediate and practical use of what they are learning, their attention will increase and so will their comprehension and retention. Making personal connections requires that the content take account of students' cultural and ethnic diversity, and that the instructor have knowledge of and respect for it.
2. Relate science learning to future careers and demonstrate the growing importance of mastery in these areas to employment opportunities. This is another way of demonstrating the relevancy of the subject .
3. Be Sensitive to cultural and language differences. Children who are used to assuming responsibilities and functioning autonomously at home will learn better in a more independent situation. Students used to using a nonstandard method of communication should be allowed to learn and express themselves in that way. Of course the instructor must be willing to "translate," if necessary.
4. Use anxiety-reducing strategies. The competitive classroom setting in anxiety producing for females and many minorities. The situation in which everyone is raising their hands to give the one correct answer is competitive. Cooperative learning is a technique whereby students work together to discover and answer, or complete a task. The pooled knowledge and skills of the group are used to accomplish the task. Differences of opinions are heard, individual skills are appreciated, and team building is accomplished. Larger tasks can be undertaken when the members of the team take on the appropriate sub problem for their abilities and personality. Within the group the

larger task can be broken down into manageable components and these smaller tasks can more successfully be accomplished, giving the student confidence. Cooperative learning is an approach that eliminates the stress of competition and the value of conflict experienced by females and some minority students who value cooperative social interaction. Instilling in students the belief that they can succeed also helps reduce anxiety.

## Group Dynamics

The cooperative student grouping should be small and have mixed abilities. Each member can function independently to accomplish learning tasks, solve problems, and achieve a continual evolving set of goals. The task assigned and resources provided must lend themselves to independent learning with only intermittent instructor input. In order that each student in a group has an opportunity to shine within the group at one time or another, some of the lesser skilled students may be individually trained. Then those students can train the other students in the group.

You can be a part of the solution by being part of the enrichment in the science classroom. By being sensitive to the differences of the students you can be more equitable in your presentation and response to student needs. Your visit should be long remembered for the subject you bring and the role model that you portray. You will leave the students with the impression that scientists are not cold, isolated, and insensitive. This will be an impression worth remembering.

## Leave the impression that you are:

- Humanistic.
- Sensitive to gender and cultural differences.
- Not cold and aloof.
- Willing to help the public understand and appreciate your work.

## Summary:

Do what teachers can’t do.

Show them that scientists are humanistic and sensitive to individual needs and differences.

Students need help in making the jump from theory to application and you can help.

Expand the students’ ability to apply knowledge.

Small group activities may provide the best vehicle to explore science.

Verbal interaction improves learning.

Ask for clarification when necessary.

Parenting molds the student.

Racial and cultural bias restricts interest in science.

Beware:

Exclusive language always excludes someone.

Inside jokes put most people on the outside.

Remember:

The sexes are different, but equal.

In taking into account the “gender factor,” you will need to compensate for certain stereotypes, which are firmly in place in the society as a whole.

The females’ place is in the lab

Don’t teach the whole course!

People remember the information they use and lose the rest.

## References


**Books:**

Banks, James. Multiethnic Education Theory and Practice, Second Edition. Allyn and Bacon, Inc., Boston.1988.

Gardener, Marjorie et al. Toward a Scientific Practice of Science Education. Lawrence Erlbaum Associated, New Jersey, 1990.

Hersey, Paul & Blanchard, Denneth H. Management of Organizational Behavior. Prenctice Hall, New Jersey, 1988.

Truell, George F. Coaching and Counseling : Key Skills for Managers. PAY Publications, Buffalo, New York, 1981.

**Reports:**

Clewell, Beatrice Chu & Andersen, Bernice. Women of Color in Mathematics, Science and Engineering: A Review of the Literature. Center for Women Policy Studies. Washington, D.C., 1991.

Denno, Devorah and others. (Aug 81) "Early Cognitive Functioning: Sex and Race Differences." Paper presented at the Annual Meeting of the American Psychological Association.

Educating Americans for the 21st Century: A Plan of Action for Improving , Mathematics and Science Technology Education for All American Elementary and Secondary Students So That Their Achievement is the Best in the World by 1995. National Science Board Committee on Precollege Education in Mathematics, Science, and Technology, 1983.

How Schools Shortchange Girls. The AAUW Report, Commissioned by the AAUW Education Foundation, 1992.

Schwartz, Wendy (Sep 87) Teaching Science and Mathematics to At Risk Students. Office of Education Research and Development, Washington, D.C.

Strategies for Increasing Involvement of Research Scientists in Implementation of Innovative Science Educational Programs. A Report Prepared for the Educational Research and Improvement Branch Office of the Assistant Secretary for Educational Research and Improvement, United States Department of Education. Washington, D.C. Mar 83.

**Periodicals:**

DeRose and Randy D. Krauss. The Scientist, October 27, 1997. Volume 11, page 9.

Gallager, James. "Prospective and Practicing Secondary School Science Teachers' Knowledge and Beliefs about the Philosophy of Science." Science Education. 1991, 75; 1: 121-133.

Kerr. "Women and Minorities in Science," Science Education. 1991, 75; 3: 367-370.

Willis, Madge Gill "Learning Styles of African American Children: A Review of the Literature and Interventions." The Journal of Black Psychology 1989, 16; 1: 47-65.

Personal Communications:

David Sadker, professor at the School of Education at American University, Washington, DC. Coauthor of The Sex Equity Handbook for Schools. Telephone interview, 22 April 1992.

Callahan, Carolyn M., professor of Educational Studies, Curry School of Education, University of Virginia, Charlottesville, Virginia. Telephone interview, 27 April 1992.