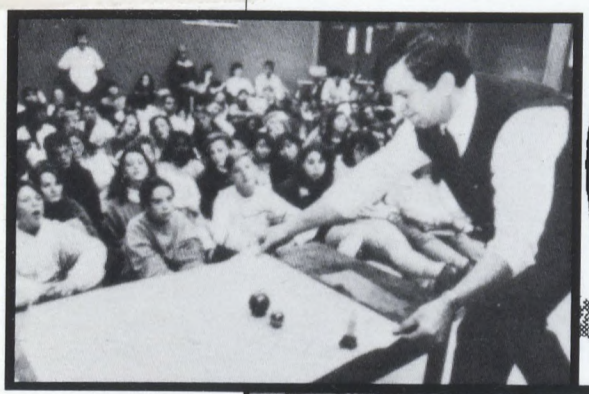
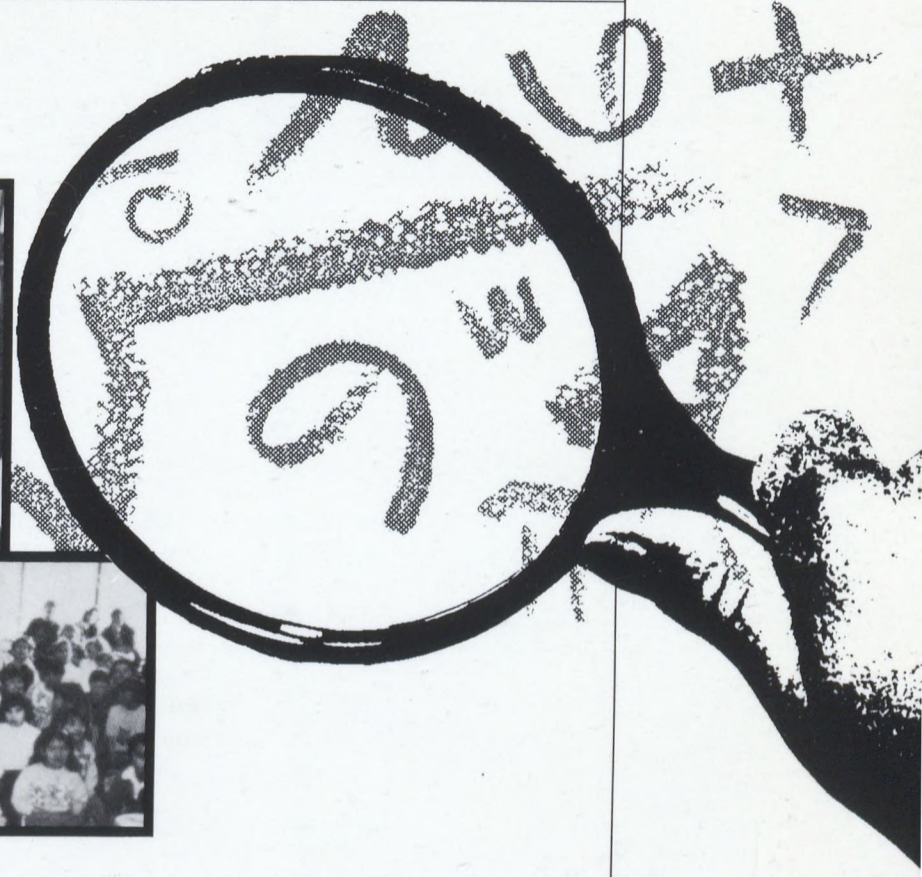
SELLING SCIENCE TO STUDENTS

A Guide for
Frontrunners and Innovators in the Schools





SCIENCE + MATH = YOUR FUTURE

Fourth Edition

March 1995

Ce rapport est également disponible en français.
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Three years ago, British Columbia's Ministry of Advanced Education, Training and Technology, initiated the first major *Scientists in the Schools* Program in Canada, placing scientists, engineers and other professionals directly in the classroom. Similar programs have been launched in other parts of Canada under the federal/provincial initiative, *Innovators in the Schools.* The success of theses programs proves that kids get more interested in science when they get a chance to see a real scientist, engineer, technician or technologist in action.

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ATTENTION INNOVATORS AND FRONTRUNNERS:

Programs like Innovators/Frontrunners in the Schools rely on government and corporate financial support. These organizations need to hear that the Networks are working successfully, especially if continuing funding is being requested of them.

During your Innovators/Frontrunners school visit, ask your contact (teacher, guidance counsellor or principal) if they valued your visit and wish to support the Innovators program. If so, encourage them to convey their appreciation in a letter from their students (individually or as a class project) to the Federal Minister For Science c/o House of Commons, Ottawa, K1A 0A6, or their provincial Minister of Education.

SUGGESTIONS FOR A SUCCESSFUL PRESENTATION

Research shows that effective engineering or science presentations have a positive impact on students' attitudes towards science and math. There is also evidence that these presentations inspire students to reconsider their course options with an eye to pursuing science and technology-related careers.

Based on the experiences of *Scientists in the Schools'* presenters, you are bound to succeed if you follow these suggestions:

Be enthusiastic. Enthusiasm is contagious. It is an important tool in breaking down barriers. The successful presentation entertains, motivates and educates students. Try to include these elements in your presentation.

Know your audience. Talk at the students' level. Avoid scientific jargon and explain concepts in simple terms. Don't overload them with facts.

Grades K - 3 Presentations

Very young children learn by touching, tasting, smelling, hearing and seeing things. Children at this age level like dramatization, puppets and toys. A variety of hands-on activities is mandatory.

Grades 4 - 7 Presentations

Hands-on experiences work best. Also use slides, videos and a variety of specimens and models to achieve a fast-paced presentation. Basic concepts should be used and explained in simple terms.

Grades 8 - 9 Presentations

Again hands-on experiences are very effective. Students like slides, videos and a fast-paced presentation. Concepts can be more advanced but still need to be explained in simple terms.

Grades 10 - 12 Presentations

According to a survey, students at this level are interested in hearing general presentations about careers in engineering, science and technology. Single topic presentations, eg: engineering, should therefore include a general careers in science and technology element. Lecture type presentations are acceptable if the topic is of great interest to the students. Use a variety of resources eg: slides, videos, charts, pictures and models. Allow at least one quarter of the time available for discussions.

For more information on each grade level refer to the 'Audience' section

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Allow students to discover their own answers before giving them the facts. They will remember those 'discovered' answers better and will have a better attitude towards learning.

Relate your topic to the students' world.

Show how it affects them and how they can apply this knowledge in their daily lives.

Involve students right from the start.
Pose a problem or ask a question to hook the students' interest. Involve all of the students not just a selected few. Also, involve the teacher as much as possible.

Establish a friendly rapport with students and teachers.
Treat teachers as partners.

Be prepared but flexible.
Have an approximate timeline but realize that, due to students' interest or questions, you may take longer than anticipated.

Encourage students, especially girls and young women, to continue with science and math in high school.
Explain that they will have to complete science and math courses in high school to keep their career options open. Of post-secondary institutions, 85 per cent are closed to students who have not successfully completed high school science and math courses.

Presentations to smaller audiences are more effective than those given to a large number of students. Students like to be directly involved which is only possible if the audience is fairly small. Hands-on presentations are more effective if given to groups involving fewer than thirty students.

This guide contains many other valuable hints to make your presentation a great success.

INTRODUCTION

A NEED FOR *FRONTRUNNERS/ INNOVATORS*

Canadian industry and the academic community are experiencing a shortage of qualified scientists, engineers, technicians and technologists. Students are not earning the qualifications to fill these positions because of a lack of awareness of science and technology, they do not know of the careers available and they have not taken math or science courses at the high school level. This shortage could increase as the country moves closer to a diverse information- processing and manufacturing-based economy. The *Innovators in the Schools* and the *Canada Scholars Frontrunners* programs were developed to address this need in Canada, as well as to increase a general awareness of science and technology.

Role models are a vital factor in shaping attitudes towards engineering and science. By sending out volunteers to schools across Canada, the *Innovators in the Schools* and the *Canada Scholars Frontrunners* programs are providing these role models, helping to shape students' perceptions of careers in engineering, science and technology and encouraging them to pursue studies in these areas.

Through a classroom visit by a volunteer, students can gain some understanding of what a career in engineering, science and technology could be like, the work that can be done, and the rewards that can be expected. But above all, students can see the enthusiasm that comes from a person who 'does engineering, science and technology'.

It is highly recommended that you as a volunteer visiting a classroom, do the following:

- encourage students, particularly girls, to continue to pursue mathematics and science subjects;
- stimulate an interest in engineering, science and technology–based careers, emphasizing especially the new and exciting prospects for women in these fields; and,
- promote awareness of the Canada Scholarships Program (CSP) among students, teachers and guidance counsellors, encouraging eligible students to apply for a scholarship. For more information on this program please refer to the Appendix.

Presenting a positive image of engineering and science is crucial for the success of your presentation.

In *Loving and Beyond*, Jack Hassard presents a humanistic view of science that applies to engineering as well. This view may be helpful as you begin to think about your presentation.

1. Science is a human experience. It involves humans looking out at their world.

2. Science usually involves a co-operative human effort. The scientist alone, high in an ivory tower, is an inaccurate view of the scientific role.

3. The basic processes of science, such as discovering, valuing, and exploring, are applicable to many of the human social problems that people face.

4. Certain products of science, as transmitted through technology, can be used to alleviate human suffering resulting from poverty, disease and illiteracy.

5. The essence of humanism, as we see it, is that each human being should be encouraged to utilize her or his full human potential, as well as intellectual and social potential.

Engineering and science are really all about people. So, welcome to the world of the *Frontrunners/Innovators* programs and the challenge of capturing students' imaginations. Whether you're a newcomer or an old-timer at making student presentations, we hope that you will find this kit useful.

THE PROBLEM OF IMAGE

In making a presentation to students, you are initially affected by their image of engineers and scientists. You want to know what they think? Ask them. Give younger students a piece of paper and some crayons. Tell them to make a drawing of an engineer or a scientist at work. Have them briefly make a sketch, and then fill in the details with crayons.

This activity has been completed by hundreds of people of all ages, and judging by the results, the following conclusions about peoples' impressions and stereotypes can be drawn.

- The engineer or scientist is usually a male Caucasian.
- The scientist is either bald or has frizzy, wild hair. On the rare occasion when the scientist is a woman, her hair is in a bun.
- The scientist wears glasses and is dressed in a white lab coat.
- The scientist is shown working alone in a laboratory rather than in an outdoor setting.
- The scientist is shown mixing chemicals or doing some kind of chemistry or physics related experiment.
- The scientist is shown experimenting with dangerous things and is sometimes shown experimenting on people.

This description of the engineer/scientist stereotype is prevalent in our society. There are no simple reasons to explain why this stereotype persists. The problem we face with regard to the image of scientists and engineers is multifaceted. Television and movies have a powerful impact on our perceptions of the world. And, from the beginning, kids are given an image of a scientist that is difficult to ignore. Saturday morning cartoons begin to shape children's images of science long before they come to school.

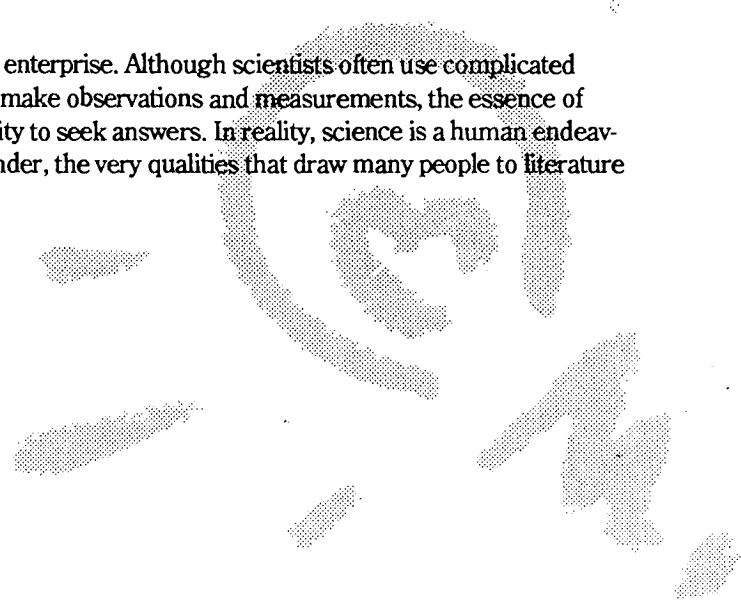
THE GOALS OF THE *FRONTRUNNERS/INNOVATORS* PROGRAM

This stereotyped impression of science and engineering is as dangerous as it is unfortunate. Science and engineering don't have to be viewed this way. They can be presented in such a way that students see the interest and beauty that they create.

There are multiple objectives for the *Frontrunners/Innovators* programs:

- By having you as a *Frontrunner/Innovator* visit the schools to speak with students, it is hoped that you will be able to communicate what science or engineering is really like.
- You can create an atmosphere whereby students will share your love of what you do.
- You can stimulate their curiosity.
- You can dispel some of the myths about science - eg. science is boring, science is difficult, science is not relevant. Show that scientists, engineers, technologists and technicians are outgoing people who usually work in teams.
- You can explain that students can benefit greatly by applying scientific methods to solve many of their daily problems.
- You can encourage students to keep their career options open by taking science and math courses in high school. Of post-secondary institutions, 85 per cent are closed to students who have not successfully completed high school science and math courses. This issue will become even more important in the future in view of the science and technology revolution our country is experiencing.
- Your job is to show that science is real, not just abstract words in a textbook, and that it can be a joyous adventure.

Science is a humanistic enterprise. Although scientists often use complicated instruments and gadgets to make observations and measurements, the essence of science is having the curiosity to seek answers. In reality, science is a human endeavour full of creativity and wonder, the very qualities that draw many people to literature and art.



LEARNING THEORY

'We learn if we have something in our hands'- *Jean Piaget*

Children are born scientists and engineers. They observe their environment and ask questions about it. They hold leaves in their hands and wonder about why these change colour in the fall. They carefully watch a caterpillar walk, curious about the rhythm. Outstanding science programs today utilize two fundamental approaches born from a child's natural way to view the world. Successful programs use a hands-on approach and involve problem solving. They go together with small group work, which also helps bring about a more positive student attitude as well as improved social development.

The 'hands-on' approach is very important, especially with elementary school children. They have not yet developed complex abstract thinking skills and need examples in order to understand. By having a direct, concrete experience, the children will have a better understanding of explanations and discussions that come later. These types of activities are also useful as an effective way to concentrate the attention of young people.

Problem-solving is sometimes called inquiry and discovery teaching. Education already has shown that children learn science better if they participate in searching out and building ideas for themselves and finding their own answers. This means avoiding just 'telling them the facts'. Children, by action and by discussion among themselves, discover their own answers. They will remember those 'discovered' answers better and will have a better attitude toward learning.

By using small groups, children learn to co-operate. By trying to solve problems, make things work and explain their actions to each other, children are forced to think more clearly and more deeply about a subject than by working alone. The result is more effective learning.

Engineering is a very human science. It is about designing, innovating and problem solving. It is challenging, fun and can be a rewarding career.

We recommend that you focus on the process of engineering and show children how ideas from engineering can be useful. For useful ideas, please refer to the attached lesson plans.

Glenn Brown, an expert on science education, writes in *Engineering for Children* that children are natural engineers but are unaware of it. Engineering has many features that make it very interesting for elementary age children. It is an excellent means to introduce basic scientific concepts, teach problem solving, and foster a positive attitude towards science and technology. Most people equate engineering only with its results. The rockets, highways, bridges and radios that have been built by engineers are much better known than the process of engineering by which these were built.

THE AUDIENCE

Before any presentation, it is important to know the audience. In the school system, each grade has specific characteristics that sets it apart from all the others. If you really want to get your message across, you need to know a little about the students you will be visiting.

Although all students act as individuals, the following list will give you a summary of what you can expect from each grade group.

Young Children K - 3

Young children do not learn by mere instruction nor can they be expected to recite facts. When children participate in a variety of hands-on activities they find it easier to learn. If the activities are carefully selected and appropriate to their age, children will enjoy science and will be motivated to continue exploring on their own.

In *Experiences in Science for Young Children*, Ronald Newman emphasizes the importance of experimental learning in early childhood. Adolescents are able to learn by hearing and reading because they have experiences with their environment. These experiences have become part of their cognitive thought. On the other hand, young children have yet to acquire this type of knowledge. They must first be able to touch, taste, smell, hear and see things before they can understand them. Children at this age level like dramatization, puppets and toys. Talking to the teacher will make it easier to find appropriate activities for this level.

Grades 4 - 7

The key to making successful science presentations to these grades is hands-on activities. Actually touching and working with materials is very important. Because most elementary-age children haven't developed complex abstract thinking skills, they need to have a concrete example of something in order to understand it. Hands-on activities provide that kind of experience. For example, it is better to start with airplane construction activities before introducing explanation of flight. This may not sound 'logical' to an adult. But the result of this sequence is that each child will know something about planes and flight, by direct experience, and so will have a better understanding of the explanations that come later. Furthermore, such participatory activities are particularly effective ways of concentrating the attention of young people.

Educational research has shown that children learn engineering and science better if they participate in searching out and building ideas for themselves and finding their own answers to questions. When using an object for demonstration, you could ask questions about the object instead of telling them right away what it is. This way, the children may figure out on their own what it is and what its purpose is. They remember those discovered answers far better than things they are merely told or read.

Grades 8 - 9

Research has shown that this age is extremely important for creating a positive attitude toward science and engineering that will carry on into a student's future life. Your personal rapport with the students is of utmost importance.

It is best when dealing with students in this age group to get them involved in the presentation as soon as possible. They are easily bored and often appear critical. Again, hands-on activities are very effective. This age group has a longer attention span than the elementary group, and can handle more advanced concepts. However, it is still necessary to explain these concepts in simple terms.

If you are using a hands-on activity to show an engineering or science principle, try to have the students come up with their own answers before telling them the correct response. This technique will not only keep the students more engaged in the presentation but it will also show them the scientific method in action. Don't be too concerned if you initially get little response from the students. At this age they are trying to be 'cool'.

Grades 10 - 12

At this level, students have developed more complex thinking skills. However, some students will be high achievers (take notes, ask questions) and others will be low achievers (appear apathetic). If you want to give a single topic presentation, try to present something hands-on.

A lecture-type presentation is acceptable if the topic is of great interest to the students. Use as many resources during the presentation as you can (eg: slides, charts, pictures, models, etc.). Even here, it is advisable to keep the presentation simple. Use language that the students can understand and avoid technical terms as much as possible.

Students at this level are generally interested in hearing presentations about careers in engineering, science and technology. Thus, even single topic presentations should include a section on careers in engineering, science and technology. Try to have your career section be as broad as possible rather than focus on only your area. Finally, make sure you allow at least one quarter of the time available for questions and discussions.

SPECIAL GROUPS

Special considerations should also be given to other segments of the population. *Frontrunners/Innovators* can play an active role in encouraging both young women and First Nations children in science, engineering and technology.

Girls

Studies have shown that girls lose interest in science, as they get older, much faster than boys. They often become discouraged or begin to believe that they aren't as good at such activities or that they just aren't supposed to show an interest in science. These attitudes are partly caused through social patterns outside the classroom and partly by teachers often giving boys more time to answer questions in class discussions than they allow girls.

As girls tend to have less confidence in their own abilities in science, they need to have more encouragement. Getting them involved is very important. If you need students to help with a demonstration, pick girls as well as boys.

First Nations Children

Similar strategies will help with First Nations children. What the First Nations child generally finds in school is a culturally-incongruent situation. This incongruence can be seen in the chart below from *New Strategies in Indian Education*:

School	Native Child
Authoritarian – teacher decides what goes on (control by others).	Egalitarian – child and peers decide what goes on (control by oneself).
Restricts movement.	Freedom of movement.
Individualistic.	Group-oriented.
Competitive and performance-oriented.	Co-operative or competitive in groups of peers.
Verbal dimension is stressed.	Visual-spatial, kinesthetic dimensions stressed.
Linear, step-by-step sequence of learning (analytic).	Holistic learning.
Most experience is indirect.	Direct experience.

The First Nations people see teaching firstly as the art of working out social relations, and secondly as a means of conveying academic materials. Respect for the rights and points of view of others is primary.

Thus, the presentation style suggested (hands-on, problem-oriented, small group) would seem to fit the learning style of the First Nations child. It is holistic learning that allows a more multi-dimensional experience.

PLANNING: COMFORT, CONTACT & CONTENT

COMFORT

Being an Innovator/Frontrunner volunteer should be fun.

The first step of planning is for yourself – plan to be at ease and to enjoy yourself. This program will only be effective if you can comfortably convey something of yourself in the classroom. Finding that comfort may be simpler than you think. Here are some recommendations:

Aim to share some special things about yourself:

- *Your Enthusiasm*: 'I'm really pleased to be here today because I really enjoy what I do and I'd like to share it with you.'
- *Your Wonder*: 'You know, I've always wondered if we'll ever communicate with life on another planet ....'
- *Your Work*: 'The project I'm working on now is really exciting ....'
- *Your Lifestyle*: 'My work takes me to France sometimes, and that's great because I'm trying to perfect my French cooking ...';
- *Your Dreams As An Innovator/Frontrunner*: 'If I ever win the Nobel Prize, I hope it will be for ...';
- *Your Route To Innovation*: 'It's funny, I always thought I'd be a lawyer, but .. .'
- *Your Experience*: 'Now's a great time to think about careers in my area, especially for young women, because the opportunities are ....'

Be humble rather than authoritative:

A few honest 'I don't know's' can inspire more than a host of facts.

Be casual.

Talk, rather than lecture, and convey a few clear ideas, rather than survey a complete subject.

Be innovative with materials, and with your approach to demonstrations, activities or content.

Try to entertain, educate and motivate.

CONTACT

Every effort for effective contact with the teacher is worthwhile. **Treat the teacher as a colleague.** An ally in the classroom will enhance your visit and help to create future *Frontrunners/Innovators*. Here are some ideas...

When the teacher calls, be ready with your thoughts and questions:

- Ask the teacher what he/she wants you to do. If the teacher has no specific request suggest those activities you are most comfortable with. **Keep in mind the main purpose of your presentation is to inspire students and not to teach facts.**
- Find out where they are in the curriculum. If possible try to fit your presentation into this, thereby enhancing the value of your presentation as a learning experience. You may want to offer your on-going help to enrich the science/math curriculum.
- Age of students.
- Size of class.
- Details of location and time.
- Audio-visual needs (it is generally advisable to bring your own equipment whenever possible).
- Group description – how does the teacher describe the class, group dynamics, special interests, special students?
- Teaching formats – does the teacher recommend a format or activity which the students are used to, or that works particularly well with them?
- Content feedback – how appropriate are the content, props, demonstrations and/or activities you had in mind for the level, interests and background of the students?

Prepare an informal briefing sheet about yourself which can be mailed or faxed to teachers, saying in simple language:

- Who you are.
- What you do.
- Where you work.
- What you'll be presenting (a brief outline, including central ideas, basic format, and tools/props/demos/activities).
- Some personal information (as in a biography - interests, hobbies, birthplace, family, education)
- How you would like to be introduced. Try something which naturally incorporates your biographical information and work details rather than 'This is Dr. _____, who is a _____.'

Prepare some pre-visit activities for the teacher to do with the class which will set the stage for your arrival. Some ideas are:

- A simple demonstration, experiment or data collection activity, even if only generally related to your topic (eg., an astronomer might suggest a constellation-learning exercise, or a take-home star gazing session; an engineer might request ideas for applying a new technology). A point to remember is that teachers usually have access to classroom experiment manuals which might have a prepared example of the topic you suggest. As well, you might consult colleagues and professional organizations associated with your work for materials they have prepared or used. In general, lots of resources are available and you can help direct the teacher to these.
- A set of questions about your job, your ideas, or about the world in general that can help the teacher lead classroom discussions (eg., for younger grades, 'What does an astronomer do?', and for intermediate grades, 'What tools does an astronomer use, and where?', and for senior grades, 'What courses do you need to be an astronomer, and what career opportunities are there?').
- Posters, photographs, pamphlets, career brochures, popular magazine articles, or other general display materials. Once again, professional organizations can usually supply these.
- A creative activity involving art work, drama or writing which will stimulate thinking (eg., for primary grades, 'Draw a picture of what it would be like to live on the moon'; for intermediates, 'Act out, as a class, the orbits of comets around the sun'; for seniors, 'Write a brief statement about your opinion on whether it is better to send a manned or unmanned mission to Mars.').

Discuss with the teacher how you can best work as a team during your visit. Some aspects of this teamwork might include:

- Arranging to meet the teacher briefly ahead of the class to discuss strategy.
- Suggesting some good questions to have asked during your presentation.
- Presenting a demonstration together (make sure that such a task provides the teacher with a meaningful role; otherwise, a student might be better).
- Have the teacher organize student participation or involvement in an activity, demonstration, or debate.

Teachers are professionals and wonderful assets to your visit; make every attempt to include them effectively.

CONTENT

Planning the content of your presentation is a combination of sound self-knowledge and some proven principles. No single formula or lesson plan will work. Here are some general points to consider:

- **Don't try to do too much:** don't talk technically or talk down; don't overdo answers to simple questions.
- **Quality:** Whatever you do, do it well. Poor photocopies, poor slides, poor equipment and poor preparation are immediately recognizable at all levels, and will reflect poorly on you and your message.
- **Action:** Keep it moving. Plan for changes of pace and format. For example, look to engage attention immediately with some initial activity or challenge (eg., a demonstration, a provocative statement, an unusual prop, etc.). Try to establish a content flow with regular punctuations for group activities, questions, demonstrations and new ideas.
- **Participation:** Everyone learns and remembers better through participation rather than just listening to a 'talking head'. Participation can be achieved on a number of levels:

  Whenever possible, provide a hands-on group activity as a concrete demonstration of what you do (eg., examining slide specimens and recording observations; building a structure with provided pieces; disassembling a component with tools provided).

  Provide pass-around samples of what you do (take-home if possible). These can be botanical specimens, meteorite samples, circuit boards, material samples, etc. Anything to engage the mind through touch.

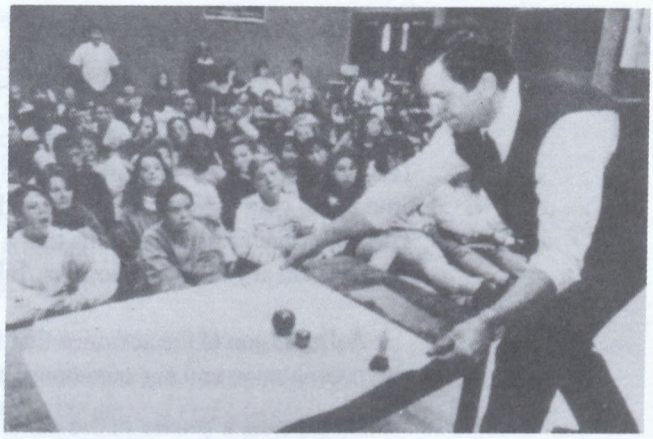
  If touching isn't possible, bring along an intriguing prop - working or otherwise - to engage attention (eg., a telescope, a clean-room costume, a manufacturing robot arm, a set of electrophoresis gels).

  With adequate lead-in and teacher support, **initiate and moderate or stimulate a lively debate on some central or sensitive issue** (eg., for elementary students – 'What do you think happened to the dinosaurs?', 'Is there intelligent life elsewhere in the Universe?' or for secondary students – 'How can science save the environment?', 'Is clear cutting good forestry?').

- **Sensitivity:** Be aware of larger issues facing engineering, science and technology, and address a few if you are comfortable and capable. Some examples:

  Female Frontrunners/Innovators. Provide personal and/or historical examples of successful women in your field, and discuss lifestyles and career opportunities for young women.

  First Nations Frontrunners/Innovators. If you can in your area, blend traditional knowledge and beliefs with modern ones, and relate the cultural necessity of innovation.



VANCOUVER SUN

  Frontrunners/Innovators Are Not Necessarily Geniuses. Most students don't perceive themselves as being 'smart', and so exclude innovator careers from their dreams. Discuss the qualities that really define an innovator.

  Frontrunners/Innovators Don't All Need Calculus. Many students also exclude themselves from the possibility of being innovators because math isn't their best subject. Discuss areas of science, technology and innovation which don't depend on high-level mathematics.

  Frontrunners/Innovators Are Helping To Save The Earth. Take some time to give a balanced picture of the environmental, social and economic accounting within your area.

  Frontrunners/Innovators Are People. Discuss the lifestyle advantages of the innovator in terms of job versatility, intellectual freedom, challenge, creativity, family and income.

For information on how to deal with different grade levels, please refer to the chapter on 'Audience'.

DELIVERING A PRESENTATION

THE TEACHER AS A RESOURCE

Although most of you will have contacted the teacher by phone prior to your presentation, it is important to arrange to have 'face-to-face' time before meeting the students. The teacher can be a valuable resource to you and your first link to the students. Teachers often have a distorted idea of what a scientist or engineer is like. Spend some time being yourself, asking advice and suggesting involvement in your presentation. The important first impressions that a student will then glean from their teacher's introduction of you will be positive. Information may be obtained from the teacher by:

- A discussion of the activities that the class has done in preparation for your presentation and any questions that may have arisen.
- Requesting a 'profile' of the class. One class of students may be completely different from another class of the same age. This will affect the nature and pace of your presentation. Teachers are usually eager to tell you about their class and are very honest and forthcoming. You can get an idea of student capabilities and whether they are enthusiastic and willing to participate. There may also be a student or group of students that the teacher feels you should be aware of. These may be students who are likely to monopolize the conversation or who are bright and interested but shy and reluctant to participate unless prompted.

The level and type of involvement of the teacher is obviously dependent on the nature of your presentation. **However, it is important that the teacher be present and as active a participant as possible.** Generally, the interest of the students is dependent on the interest expressed by their teacher. Some suggestions for including the teachers are:

- Asking for their assistance in forming groups of students for specific activities.
- Requesting participation in a demonstration.
- Encouraging them to help the students to form and ask appropriate questions and to channel their enthusiasm.

FIRST IMPRESSIONS

The initial few minutes of your presentation will set the stage and provide you with valuable information about the nature of your audience. As mentioned above, the introduction by the teacher is crucial. We've discussed the typical student's stereotyped image of a scientist. Visually, many of you will dispel this image. The fact that some of you are female scientists speaks for itself and requires no explanation. However, during your presentation students should be reminded that females can be scientists. To put the idea of being 'smart' into context requires a bit more skill. Children often believe that they cannot relate to this 'smart' person and will be initially reluctant to interact. Some suggestions to deal with this include:

- **Being enthusiastic and excited about what you do.**
  Enthusiasm is contagious and an important tool in breaking down barriers.
- **Involve the students immediately by:**

  Relating to them and their experiences.
  'When I'm walking along the beach, I like to flip over the rocks and see what's underneath. Do any of you like to do that?'

  'Did you watch Star Trek last night? What do you think of the Empath?'

  Expressing interest in their questions.
  Most questions are not stupid and deserve positive acknowledgement. Make a comment such as 'great question!' or 'Can any of you answer _____ 's question?' Always ensure that you repeat a question asked so that it has the attention of the whole class.

  Stimulating their interest and curiosity.
  'What do you think will happen if I add this white solution to the pink solution?'

Remember that different groups of students act differently. It is during these first few minutes of active exchange of information that you cannot only break down barriers but, with the aid of the teacher's comments, get a feel for your audience. Do they like to question? Are they active or reflective? Are they interested in knowing specific facts or are they looking for a 'big picture'? Do they seem to be task-oriented or flexible? These learning styles are easier to determine with younger students who are more open and responsive.

QUESTIONS AND QUESTIONING TECHNIQUES

Some words used in asking questions, such as *can*, *does*, *should*, and *would*, ask for a 'yes' or 'no' response and usually end the discussion. This problem can be eliminated by rephrasing the question, using one of the interrogative forms, such as *how*, *what*, *when*, *where* or *why*. This questioning strategy is not meant to elicit one word answers or specific technical facts. Thus questions such as 'What do you think would happen if ...?' or 'Why do you suppose...?' will bring about greater class discussion.

FURTHER TIPS:

- Have an approximate timeline for the components of your presentation, but be prepared to be flexible. Sometimes a class will lead you in a different direction than you anticipate or take a longer or shorter time to grasp concepts or perform tasks.
- Be cognizant of the age level you are relating to. Younger students generally will respond to a more fast-paced, variable format.
- If using jargon that you are familiar with enhances your presentation, be sure to define the terms.
- Children express honestly what they feel. Inattention, non-directed chatter, or discipline problems could indicate boredom or lack of understanding. Use eye contact to actively monitor your audience. It is usually much more difficult to detect the impact of your presentation with 13 - 15 year olds. Peer pressure is intense and it is not 'cool' to show interest. Do not be discouraged if you encounter this reaction.
- If you ask a question, be sure to give students sufficient time to formulate an answer. There will always be those who will answer immediately when a question is posed. However, some need time and should be given equal opportunity to respond.
- Encourage active participation and use hands-on activities when appropriate. Small group activities are often useful as children like to share ideas, learn from each other and capitalize on each other's strengths.
- If you are asking students to perform a task, ensure that the instructions are very clearly laid out and a time limit is given; i.e. you have five minutes to complete this task. They are embarking on something new and may become inattentive and disruptive if they are confused. The teacher may be useful to you in explaining the activities.

- Effectively use visual materials. You may have a flyer, poster or other prop that the teacher can give the class prior to your presentation to help stimulate interest. Also, children like to take something tangible away from their task-oriented experiences. If something reaches home, parents also become more informed and interested in science. Videos and slide presentations can also be useful as long as they complement your presentation and are not too long.
- Do not be too specific about your job at first. As the students become more comfortable with you, they will naturally be more curious about what you do and why you are interested. Keep your descriptions brief and enthusiastic and refrain from lecturing. Don't frighten them with jargon.
- Above all, be yourself. Children are perceptive!

For information on how to deal with different grade levels, please refer to the chapter on 'Audience'.

CONCLUSION

Your main goal should be to leave the students 'on a high'. Hopefully, you will succeed in encouraging students to be curious and consider keeping the doors to careers in science and mathematics open.

FOLLOWING UP

The *Frontrunners and Innovators in the Schools* programs are really about people. *Frontrunners/Innovators* share their knowledge and love of science in schools with startling results. What began as a single visit may evolve into a more long-lasting contact. **The contact between Innovators, Frontrunners and school teachers will help bridge the cultural gap between the science/engineering community and the schools.**

Try to imagine your visit, and the impact of your ideas, beyond a single event. There are a number of possibilities for extending your contact:

- Arrange with the teacher to visit the class more than once, building on content or continuing an experiment.
- Arrange with a colleague or professional organization to provide follow-up content or services.
- Provide the teacher with ideas and/or materials for feasible post-visit activities in the classroom.
- Suggest and facilitate a field trip which will reinforce your content, possibly booking a visit to your own work place or a related concern in the local community.
- Suggest safe, simple home projects related to your work which individual students might pursue, possibly in direct contact with you or another responsible professional.
- Leave your name and contact points with the teacher and students, encouraging future contacts.
- Provide names and contact points for individuals, institutions, professional organizations, societies, clubs and companies which have resources and activities that might cultivate the interests which you are trying to encourage.

Contacts are not limited to the schools you visit. Share your experiences with other program participants.

APPENDIX

A Guide for
Frontrunners and Innovators in the Schools

PLANNING SHEET/TEACHER CONTACT

School: _____

Teacher: _____

Address: _____

Phone Number: _____

Grade of Class: _____

Size of Class: _____

Location of Room: _____

Time of Presentation: _____

AV needs: _____

Class descriptions: *(general comments, special interests, recent studies, etc.)*: _____

Teaching formats: *(How does the teacher normally work with the class?)* _____

Content feedback: *(Describe possible presentation, activities, etc. and get teacher response)* _____

Teaching suggestions: _____

PLANNING SHEET/PRESENTATIONS

Introduction: *Brief description of who you are and what you do.*	Time Allowed
Presentation: *Problem and/or question to hook student interest*	
Demonstration - Props	
Hands-on Activity	
Content: (Reinforce that students should continue to take courses in science and mathematics.)	
Question Period	

BRAIN TEASERS

Short brain teasers can serve as a stimulating introduction or an end of presentation filler. These can be done with students individually or in small groups.

1. You've heard the threat, 'I'll break every bone in your body.' In order to do it, how many bones would you have to break, approximately 200, 2000, or 20,000? (*200*)

2. Is a zebra black with white stripes or white with black stripes? (*White with black stripes.*)

3. Which would you estimate to be the greater sum, that of the figure on the left or that of the figure on the right?

987654321	123456789
87654321	12345678
7654321	1234567
654321	123456
54321	12345
4321	1234
321	123
21	12
1	1

(*Both are the same – 1,083,676,269*)

4. Can you name ten parts of the human body that have only three letters? (*Ear, eye, lip, arm, leg, rib, hip, gum, toe, jaw.*)

5. Without stopping to think or plan, name a colour, any number from one to ten, a flower, a fruit. Compare answers with others in your group. (*The most frequent answers are: red, five, rose, apple.*)

6. Why does a whip crack? (*The whip cracks because its tip moves faster than the speed of sound.*)

7. How many pounds of food and drink does the average person eat in a year? (*We swallow about one ton of food and drink per year.*)

8. It takes 17 muscles to smile. To frown takes: 13, 17, 29 or 43? (*43*)

9. How many quills on a porcupine? 12,000, 24,000 or 36,000? (*36,000 quills per porcupine.*)

10. How many muscles does a caterpillar have: 1,500, 2,000 or 2,500? (*2,000*)

ENGINEERING

LESSON #1: AIRPLANES

Developed by Blair Yochim

FOCUS:

1. To explain how airplanes fly.
2. To give the opportunity to the children to design and see how their own paper airplanes and helicopters fly. A very popular presentation.

GRADE LEVEL:

Grades 3 - 7 (can be adapted to fit the needs of higher grades)

PROCESS SKILLS:

Science principles, manipulation skills, problem solving, creative thinking.

TIME:

45 minutes.

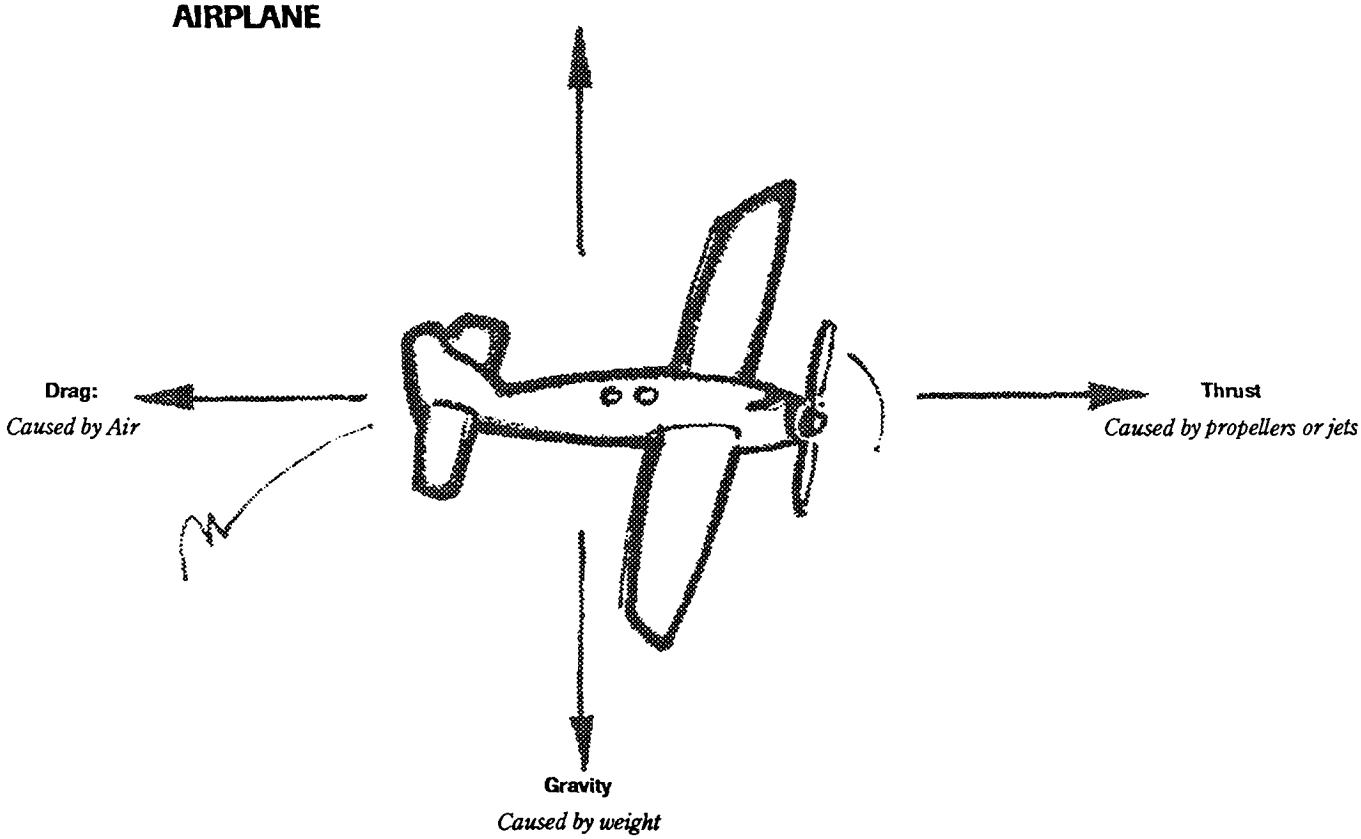
MATERIAL AND RESOURCES:

Handout as shown, 8-1/2" x 11" paper, scissors, balloon, plastic airplane model for demonstration purposes.

PROCEDURES:

1. Explain Newton's Third Law of Motion that an action causes an opposite reaction: blow up a balloon and let it go (air goes one way while balloon goes the other). Similarly an airplane propeller or jet blows one way and the plane moves in the other direction.
2. Explain how airplane wings work: blow on a piece of cardboard resting at an angle so it lifts, blow over a curved piece of paper which causes it to rise.
3. Explain the four forces on a plane with examples of what causes each force and how to minimize or maximize each.
4. Allow the children to build their own paper airplanes. Suggest that they follow the handout's instructions. Note that the proposed plane has a blunted front end to minimize risk to eyes. Enforce a 'runway' area and taking turns to minimize risk of injury. Contests or flight trials through a hoop could be conducted. Offer suggestions to those who aren't having any luck flying.
5. Show classroom how to make the paper helicopter.

AIRPLANE



TIPS ON MAKING A PAPER AIRPLANE:

Gravity:
Make it light weight.

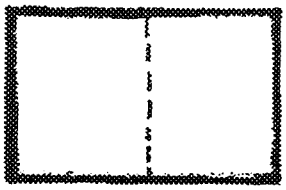
Drag:
Make it flat, thin, and smooth.

Lift:
Make lots of wing area.
Bend wings up a bit.
Try bending back end of plane a bit if it doesn't go straight.

Thrust:
Throw it straight and *very gently!*

HOW TO MAKE A PAPER AIRPLANE

1. Make a crease in the middle

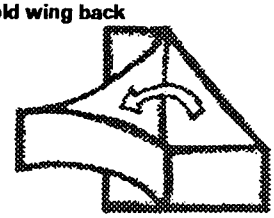


2. Make 2 folds

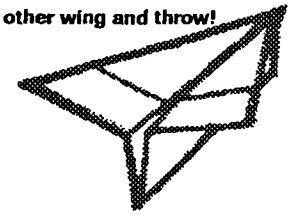
3. Fold tip

4. Fold in half

5. Fold wing back

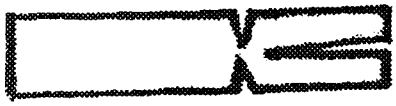


6. Fold other wing and throw!

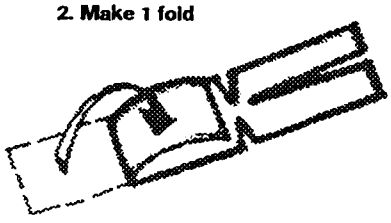


HOW TO MAKE A PAPER HELICOPTER

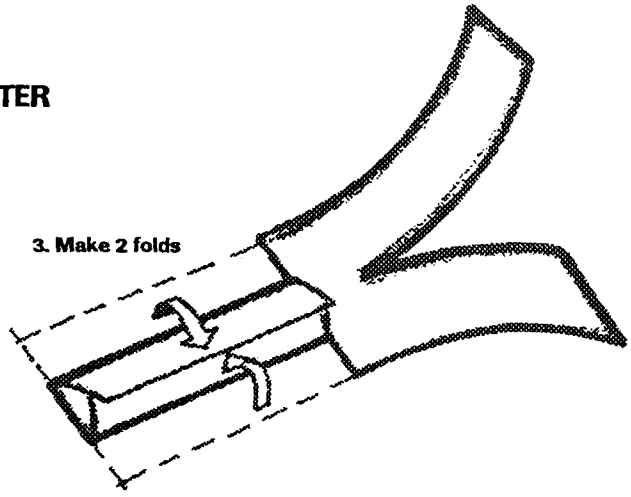
1. Make 3 cuts



2. Make 1 fold



3. Make 2 folds



4. Let it drop and watch it twirl!

ENGINEERING

LESSON #2: BRIDGE ENGINEERING

Developed by Blair Yochim

FOCUS:

The children will design and build a bridge using materials available around the house.

GRADE LEVEL:

Grades 3 - 5 (can be adapted to fit the needs of higher grades)

PROCESS SKILLS:

Problem solving, creative thinking, manipulation skills, verbal communication skills.

TIME:

20 minutes classroom, 1 week homework assignment.

MATERIAL AND RESOURCES:

See handout for examples.

PROCEDURES:

1. Using 'volunteer' children with outstretched arms and joined hands, demonstrate how the 'bridge' formed could be made stronger.
2. Draw examples of different types of bridges, after asking the children how many they are aware of. Use examples of local well-known bridges to remind the children.
3. Using a triangle and a square made of wood or Meccano, show how a triangle shape is much stronger than a square, and point out how bridges make use of this fact.
4. Assign the task to either individuals or groups, as they desire, to build a bridge using materials from home (no money spent!), and bring the bridge back to the classroom the next week. The presenter may want to build a very simple and non-intimidating bridge as an example for the children, and to better understand what the children are up against!
5. Have the children show off their bridges and answer questions: How did they choose the materials? What problems did they encounter and how did they solve them? How would they make a better bridge?

BRIDGE ENGINEERING

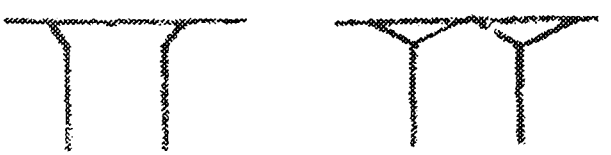
PARENTS:

Your children are involved in a program called *Frontrunners and Innovators in the Schools*. Please help them build a bridge by (date) _____
by providing materials and guidance only IF THEY REQUIRE IT.

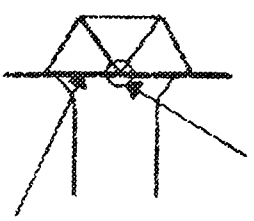
SPECIFICATIONS:

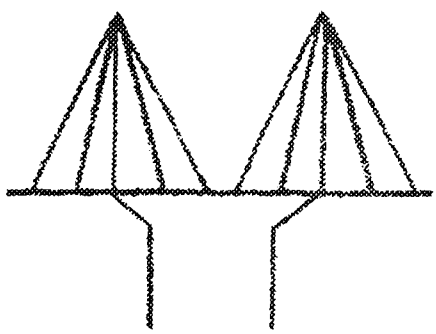
The bridge should be able to span a distance of twice the length of material, or a minimum of 20 centimetres if cardboard is used, and allow a small 'micromachine' sized car to pass over it (about 2 x 2 x 3 centimeters). (No limit on amount or type of material other than Krazy or hot glue).

EXAMPLES:

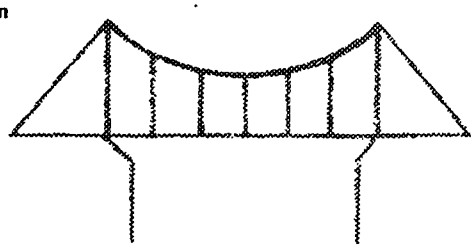


Cantilever





Suspension



BEAMS:	POSSIBLE CONNECTING MATERIALS:
Toothpicks	Plasticine, white glue, *(No Krazy Glue!)*
Popsicle sticks	White glue
Straws	Paper clips, tape, string, elastic bands
Cardboard, paper	Glue, tape, paperclips
'Meccano'	Nuts and bolts
Other Materials?	
(Wood, Styrofoam, Lego ...)	

SUGGESTIONS:

Use what's available from home (recycle!); no purchases.
Support bridge from below or above as shown.
Bridges do not have to be complex.

LESSON #3: BOTTLE AND STRAW PROBLEM

Developed by Blair Yochim

FOCUS:

To allow free rein for the children to use creative thinking in solving a simple problem.

GRADE LEVEL:

Grades 2 - 7 (can be adapted to fit the needs of higher grades)

PROCESS SKILLS:

Creative thinking, problem solving, analytical skills, group communication and interaction skills, encouragement and entertainment.

TIME:

20 minutes

MATERIAL AND RESOURCES:

A plastic pop bottle and straw for each child, attached handout if desired.

PROCEDURES:

1. Ask the children to see how many ways they can lift the bottle with only the straw. The children can work alone or in groups. As the children solve the problem in a new way, have them present the solution to the rest of the class, since new ideas can trigger other creative solutions.

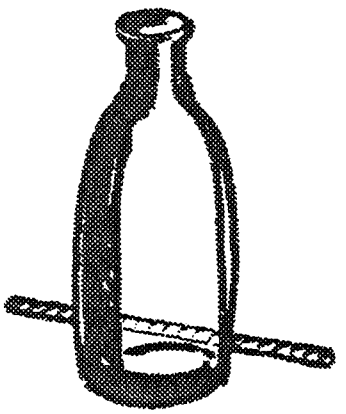
2. The technique of brainstorming, or benefiting from group interaction, could be used to demonstrate how people can come up with better ideas from witnessing other people's ideas.

   There are several known solutions:

   - tie the straw around the nozzle;
   - loop the straw around the nozzle;
   - bend the straw into a 'J' and insert it in the nozzle;
   - screw the lid around the straw;
   - freeze the straw in the bottle with ice;
   - slice the straw end apart and insert into nozzle;
   - balance the bottle on one (or more) straight or bent straw(s);
   - slide flattened straw under bottle wrapper;
   - insert straw end into depression at bottom (of some bottles);
   - lean the bottle onto a straw;
   - blow up through straw into bottle;
   - drill hole right through the bottle and insert straw.

BOTTLE AND STRAW PROBLEM

Draw or write down the ways to lift a bottle with only a straw.



LESSON #4: CARD BALANCE DESIGN PROBLEM

Developed by Blair Yochim

FOCUS:

1. The children have to design a solution to a posed problem.
2. As the children solve the problem, other design limitations will be added to increase the difficulty; a true engineering problem.

GRADE LEVEL:

Grades 2 - 7

PROCESS SKILLS:

Creative thinking, analytical skills, experimental method, problem solving.

TIME:

30 minutes

MATERIAL AND RESOURCES:

3 playing cards per child, optional handout as shown.

PROCEDURES:

1 Ask the children to see how many ways that they can balance one card on top of the other two cards. No other limiting criteria are given to the children initially which allows fairly easy solutions. The children can work alone or in groups at the discretion of the presenter. When a child has solved the problem, have the child demonstrate this to the others.

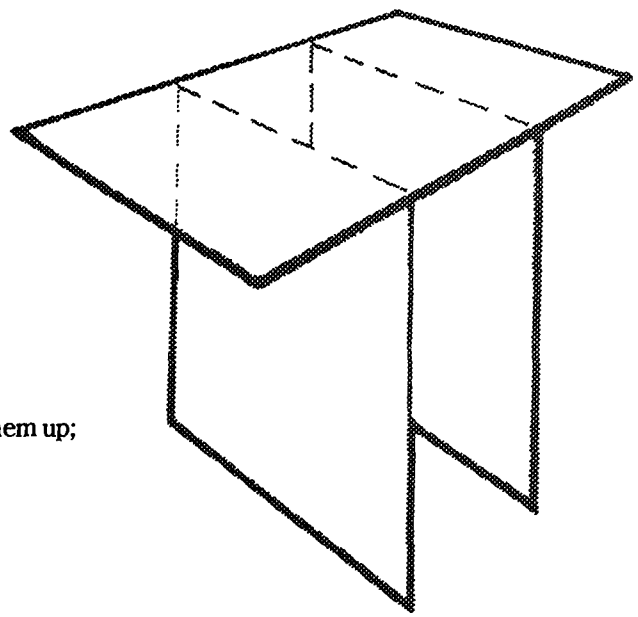
2. Every time a child has solved the problem, increase the difficulty of the problem for everyone, or for just that child, by adding a new problem criteria as listed on the handout. For example, the easiest solution to do the original problem is to simply stack the three cards. Then you can add the criteria as shown in 'A' on the handout: 'the top card must touch the other two cards'. These changes to the problem cause the children to experience a fun and enlightened creative time.
3. Note that each variation of the problem will generally make the next solution more difficult to find. After about nine new criteria were added as shown in the handout, no solution was known to the engineer who created it; but a young child did indeed come up with another original solution!
4. Suggest to the children that they take the handout home and see if the rest of the family can come up with unique solutions, and report back to the classroom.

CARD BALANCE DESIGN PROBLEM

HOW CAN YOU BALANCE ONE CARD ON TOP OF TWO OTHER CARDS?

SO THAT THE:

- top card touches the other two;
- bottom cards don't touch each other;
- bottom cards stand up;
- bottom cards are parallel to each other;
- bottom cards are on a flat surface;
- cards balance for at least a couple of seconds;



WITHOUT:

- leaning them on something else or holding them up;
- bending or cutting any of the cards;
- using any other material such as glue or tape.

A prize to the engineer who can do this!

MATHEMATICS

LESSON #5: DETERMINING PI

Developed by Blair Yochim

FOCUS:

The children will determine the mathematical constant Pi (3.14159...) by various methods.

GRADE LEVEL:

Grades 5 - 7

PROCESS SKILLS:

Abstract thinking, computational skills, estimation skills, manipulation skills, research skills.

TIME:

45 minutes.

MATERIAL AND RESOURCES:

Library, string, paper, pencils, electronic calculators.

PROCEDURES:

1. Explain the term perimeter and that the perimeter of a square is four times each length, regardless of the size. Explain the term circumference of a circle. How many times bigger than its diameter is the circumference of a circle? Call this ratio Pi.

2. See if the children can come up with ways to figure out Pi. Divide them into groups to perform the following experiments and have them write their answers on the board:

- look up the earth's measurements (library research),
- look up value of Pi (library research),
- look up I Kings vii.23 and II Chronicles iv.2 in the Bible (library research),
- measure with string around a round object (i.e. garbage can),
- measure distance a round object rolls,
- measure length of a one degree arc and multiply by 360,
- calculate $Pi = \frac{2X2X2X4X4X6X6 \ldots}{1X3X3X5X5X7}$
- calculate $Pi=4X(1 - 1/3 + 1/5 - 1/7 + \ldots)$

3. Compare various determinations of Pi. Which is closest and why? Which would be closest if given enough time? Explain that Pi has no exact value and the decimal representation continues forever without end.

BIOLOGY

LESSON #6: INSECTS AREN'T ALL BAD

Developed by Dr. Judy Myers

FOCUS:

Insects are often viewed as organisms to be avoided. The good and useful roles of insects are too often ignored.

GRADE LEVEL: :

Grades K - 12 (with changes in degree of detail)

Before the visits, students can be asked to make their own lists of what insects they think are 'good' and which are 'bad'. These lists can be considered during or after the lesson.

PROCESS SKILLS:

Thinking, observing, asking.

MATERIALS AND RESOURCES:

- Slides of different insect orders including those that have beneficial activities and those that are thought of as bad.
- Mechanical models, toys or any other insect-like characters; eg., puppets, or educational models showing insect parts.
- Insect specimens including a variety of sizes.
- Magnifying glasses.

PROCEDURES:

1. Ask whether any of the students know a scientist. Talk about being a scientist and some of the things that you do.
2. Talk about being an entomologist.
3. Talk about good and bad insects using the models.
4. Show slides discussing characteristics of good and bad insects.
5. Look at insect specimens; pass around among groups.
6. Get back together and talk about doing research on insects.
7. Answer questions: Where can students find insects?
   How can they be collected? How should they be stored?

OCEANOGRAPHY:

LESSON #7: CLEANING UP

Developed by Dr. G. S. Jamieson

FOCUS:

1. Oil spills have a devastating effect on ocean life.
2. Although it is a complicated, expensive, and drawn out process, people can clean up oil spills.

GRADE LEVEL:

Grades 4 - 7 (adaptable to higher grades)

PROCESS SKILLS:

Observing, inferring.

TIME:

40 minutes

MATERIALS AND RESOURCES:

Aluminum pie plates, feathers, chain saw oil, cotton balls, eyedroppers, bits of string, pieces of styrofoam and cardboard, nylon stockings, straws, student handout, detergent (ie. Sunlight, etc.).

PROCEDURES:

1. Opening demonstration and questions. In a pie plate of water simulate an oil spill by putting popcorn oil on the water.

   a) 'If this was a spill on the ocean, what animals may have been affected by the 'oil spill?'

   b) 'How might they be affected?' (Some may suffocate, some may be poisoned, some, like sea birds, may have their movement badly restricted as a result of the oil.)

2. Introduce demonstration: how oil affects feathers.

   Drop a few clean feathers into a basin of clean water. Watch the feathers drift lightly on the surface of the water.

   Drench more feathers in heavy oil (chain saw oil works well) and drop them into the water. Compare the two groups of feathers. Note how much heavier and more sluggish the oil-logged feathers are than the clean feathers.

   a) 'How would a bird feel if it were covered in oil?' (Heavy, sluggish; it couldn't fly.) Compare this to how you feel when you go swimming with all of your clothes on. Think of how seabirds who dive for food would get coated in heavy sludge. Hampered by oil, and having lost their ability to keep warm, the birds would soon exhaust themselves.

3. Investigation: 'Cleaning up'.

   Challenge: Oil spills pose a threat to ocean life. Find the best way to clean up after an oil spill.

   Break class into small groups (or organize as you see fit). Supply each group with an aluminum pie plate half-full of water with a small pool of oil in the middle (9 cm in diameter). Also supply each group with an assortment of cotton balls, eyedroppers, bits of string, pieces of styrofoam and cardboard, a nylon stocking, a straw, etc.

   Distribute handout.

4. After investigation, have students complete handout.

   Go through answers together.

5. Set up another demonstration oil spill. Add some detergent. Stir it up.

   a) 'What happens to the oil slick?' (It disperses.)

   b) 'What happens to the soap?' (It stays in the water.)

   c) 'What could the soap do to sea creatures?' (It could poison them.)

6. Conclusion:

   a) 'Why is it difficult to clean up after an oil spill?' (Oil is slippery and hard to handle; the water is an unstable surface; there is a lot of left-over, soiled material to dispose of afterward.)

   b) 'What could an oil spill do to an ocean food chain?' (Disrupt it by destroying one or several links in the chain.)

   c) 'What should people do to make sure this doesn't happen?' (Have rules for safety that industries must follow; clean up a spill as quickly as possible.)

EXTENSION:

What effects could chemical and heavy metal dumping have on whales? Examine the food pyramid (see handout). The humpback whale must eat tens of thousands of copepods (and other zooplankton) to stay alive. If these tiny creatures each ingest a minute quantity of poison, what happens when the whale eats a lot of them? (The quantity of poison becomes greater.)

CLEANING UP **NAME:**

1. This seems to be the best way to clean up the oil:

2. These are problems we had when we tried to clean up the oil:

3. This is what was left after we cleaned up the oil spill:

4. These are problems that you might have if you were cleaning up after a REAL oil spill:

* NOTE: Some **bacteria** will use oil as their only food source. Ocean scientists would like to plant these bacteria into an oil spill, and utilize them as a microscopic clean-up crew.

CLEANING UP ANSWER SHEET **NAME:**

1. This seems to be the best way to clean up the oil: *Answers will vary.*

2. These are problems we had when we tried to clean up the oil:

The oil is slippery and difficult to control; it gets on your hands; had to find a place to put it; used up all of our cotton balls; accidentally broke the slick up into smaller pools, etc.

3. This is what was left after we cleaned up the oil spill:

Answers will vary: students may be left with oily straws and cotton balls, etc., the water may still retain some oil; the aluminum pie plate may have remnants of oil along its edges (compare this to a beach area).

4. These are problems that you might have if you were cleaning up after a REAL oil spill:

The spill may be difficult to CONTAIN, as spills often occur in stormy weather when the ocean is turbulent. There may be a lot of oily refuse and equipment to dispose of and/or clean afterward; if chemicals or detergents are used to break down a spill, they will often be as dangerous to ocean life as the oil itself. Also, it is expensive!

* NOTE: Some bacteria will use oil as their only food source. Ocean scientists would like to plant these bacteria into an oil spill, and utilize them as a microscopic clean-up crew.

USEFUL RESOURCES

Science Experiences for the Early Childhood Years
Itarlan Jean, Columbus, Ohio
Merill, 1984
ISBN 0-675-20118-7
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