Guide to Professional Development for Out-of-School Science Activity Leaders

Developed by the N-PASS Project

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Contents

Glossary

There is varying terminology in use in informal science and engineering education because of the wide diversity of activities and programming. We have decided to use certain terms in this manual and have defined them below. We did this to define to some extent the particular audience addressed in this manual and to limit confusion about what was being described.

Activity Guide: A published set of materials, either in print or online, that provides specific directions of how to conduct investigations, design challenges, or an extended project. Sometimes these are called "curriculum guides."

Activity Leader: The person who works directly with children and youth and is responsible for carrying out activities over an extended period of time. In the out-of-school world, this person is sometimes called the "front-line staff" to distinguish him or her from managers and administrators.

Curriculum Guide: See Activity Guide.

Exploration and Play: Terms often associated with informal educational situations and often used interchangeably. However, there are important differences. See Background section for an extended rationale for making the distinction. Another term often used interchangeably but with a slightly different meaning is "investigation."

Implementation of Activities: The activity leader's carrying out of activities from an activity guide in a relatively faithful manner.

Institute: A multi-day professional development opportunity, usually with a broad agenda.

Observing Progress: An informal way of assessing how participants (children and youth) are involved in a project or investigation in terms of their social behavior and the skills as they relate to the informal learning goals of a project or investigation. Evaluation and assessment have connotations and associations of a systematic criteria based on a broader and deeper learning.

Out-of-School: Any kind of structured program that has science, engineering, and/or environmental activities as its main focus. This would include after-school programs, summer camps, and special Saturday morning offerings during the school year.

Participants: Activity leaders of out-of-school activities.

Pedagogical Practices: How activities are organized both in terms of how content is presented and the social arrangement for effective learning.

Professional Development: Workshops or institutes with the goal of promoting reflection on practice and broader goals.

Project: An extended, in-depth series of activities focused on one theme, phenomenon, or problem.

Science Activities: Activities for children or youth on science topics. They might include engineering challenges and environmental investigations.

Training: One-shot sessions that give specific instructions for carrying out activities.

Workshop: A professional development opportunity lasting from a few hours up to a full day with a specific agenda.

PART 1
Rationale for In-Depth Professional Development

There are a variety of approaches to the professional development of informal science and engineering educators. These approaches depend on important considerations, such as the goals of the activities with the children and youth and the kind of role informal educators assume in the out-of-school context. This first section outlines a general picture of out-of-school programming as currently viewed by some in this field. There are varying views of how these activities can be carried out and their purpose. There is also a broad outline of what would constitute effective professional development. These considerations should be seriously studied before you design your institutes because they determine the goals and the way you structure your institute.

<A> Science and Engineering Activities in Out-Of-School Programs

Traditionally, much of out-of-school programming has been recreational, sports oriented, or based on the arts. Within the past 10 years, especially because of federal funding such as 21st Century Community Learning Program grants, there has been a growing emphasis on making out-of-school programming more intentionally educational and academic. Partly as a result of this pressure, there is now a growing recognition that various kinds of science and engineering activities can and should be presented to children and youth. The types of programs addressing this need have comprised a wide variety of activities. Broadly, they could be categorized as involving explorations of physical phenomena, design engineering activities, or projects focusing on environmental education.

How these newer, science-related efforts are carried out will depend on how administrators of out-school programs view their relationship to formal schooling. There are varying interpretations of what would constitute this connection. Some advocate for making activities in the out-of-school context more school-like, purposely aligning them with the school content. Some have characterized this approach as having out-of-school activities supplement what happens in school. Those taking this position do allow that the out-of-school activities could be more child centered and engaging, but there still would be a deliberate attempt to giving them an academic focus.

On the other hand, there are those who advocate for an approach more in tune with the traditional goals of out-of-school programming, which focuses more on personal exploration and development. This approach could be characterized as having a complementary role to the school based on the concept that different institutions serve different educational functions. There may be some overlap in goals and activities between school and out-of-school functions, but in general these two educational institutions have different goals and culture. In an approach that would be more in tune with the traditional goals of out-of school programming, science and engineering activities can be seen as introductory and exploratory whereby they provide an experiential background for the more thorough and formal introduction of concepts in the school context. This would be in line with some formal science instructional models that have an exploratory phase as one part of a multi-phased process, for example, The Learning Cycle model and Roger Bybee's five Es.

<A>The Need for In-Depth Professional Development of Activity Leaders

There is general agreement among science educators that it takes a great deal of skill, content knowledge, and experience for inquiry, design, and environmental awareness, through science and engineering activities, to be fully implemented in a high-quality manner. In the out-of-school context, there is the perception that a majority of activity leaders do not have the requisite background and skills to carry out science and engineering activities. Therefore, there are currently real limitations in terms of the capacity of personnel as well as the overall readiness of agencies to implement programs that would offer the opportunity for children and youth to take part in these high-quality experiences. Given these limitations it is questionable whether an in-depth inquiry or design process can be carried out by after-school activity leaders.

To partly address this need, various curricula, kits, and related materials have been developed to help activity leaders carry out activities related to science, engineering, and environmental programming. These published materials do provide some kind of guidance for activity leaders, but the materials alone are not sufficient to bring about implementation of high-quality programming. There is a need for ongoing professional development. This manual provides models for professional development of out-of-school activity leaders.

It has been the experience of those conducting professional development that activity leaders have a wide range of experience, skills, and familiarity with science and engineering content knowledge. Professional development needs to take into account this diversity of skills and content-knowledge background. In addition, the level of engagement of CBOs must also be considered.

The type of professional development suggested in this manual is meant for those community-based organizations (CBOs) and activity leaders who are operating on the basis that science activities can complement what happens in school. This does not mean that they would neglect essential skills and habits of mind related to inquiry. These skills and habits would still be incorporated but not given the degree of emphasis and practice as would occur in school. The overall goal would be to help children and youth gain a deeper understanding of a phenomenon or problem to prepare them for a more thorough and systematic development in the school context.

<A>Current Practices in Out-of-School Programming

In planning for professional development of out-of-school activity leaders, it is important to have a sense of the type of programs that activity leaders carry out and constraints that they encounter, as well as the past experience of your participants.

There are currently multiple practices in the way that science and engineering projects are carried out in out-of-school programs, ranging from brief occurrences to more focused efforts. Some types of current offerings include:

- One half hour of a free choice activity once a week during the school year

- One or two 45- to 50-minute session once a week during the school year
- One multiple-hour session on a Saturday
- A summer camp program having focused projects of a week's duration for an hour or more each day

You will need to find out the intensity (hours of session), duration (entire school year or several weeks), and the level of engagement of children in the programs that participating activity leaders are conducting. This determines what you will present in your institute. Activity leaders who are conducting more in-depth programming have different needs compared with those who do not.

You also need to get a sense of the challenges activity leaders encounter in attempting to carry out activities on a regular basis as well as what the goals are of the administrators who supervise them. In the current climate of rising expectations, out-of-school program administrators are facing increasing pressure to offer a variety of activities and, thus, they shape their activities to be more educational. In larger CBOs, out-of-school programs tend to offer multiple types of activities. These include homework help, tutoring, and academic enrichment. Because of multiple demands and the growing emphasis on academic enrichment, it is very challenging for administrators to offer enrichment activities that happen more than once a week. Also, there has been the tradition in out-of-school programming to offer one type of activity once a week. Because of the increased demands on out-of-school programming, it is hard for activity leaders to establish a continuity in extended, focused projects. But the alternative, shorter, one-time projects, may mean that the activities have a limited impact on the participants. Therefore, these limitations need to be kept in mind when considering what activity leaders can accomplish in this kind of environment.

Another consideration is the background of the activity leaders. Currently, there is a great mix of backgrounds ranging from activity leaders who are high school and college students to teachers with formal training and professional volunteers who have none or very limited experience and training in working with children and youth. If possible, you will need to survey the participants in your institutes to determine how best to meet their needs.

Many of the activity leaders will not have any higher-level academic background in science and engineering. Some may have experience working with physical materials and children and youth, but this will more likely have been in craft-type activities. The lack of background in science and none or limited experience with hands-on activities usually result in activity leaders feeling inadequate and not up to the task of doing science and engineering activities. So, part of the goal of the institutes is to motivate the participants to take on this challenge in addition to providing specific ways of conducting activities and handling different kinds of implementation issues.

PART 2
Planning and Designing Activities for an Institute

Part 2 provides some practical guidance for designing and presenting professional development for out-of-school activity leaders. Working within the constraints of funding and the time activity leaders can give to professional development, you need to decide the total time for an institute, whether there will be multiple institutes for the same participants, and, if so, how long this involvement will continue with the same group. You also need to plan and design the activities for each day of the institute, taking into consideration the background of the participants. As mentioned in Part 1, it is highly recommended that published curricula be used as a model for carrying out activities. As with any manual, these suggestions are meant to provide a starting point that can be modified to suit your particular circumstances

<A>Planning and Presenting Professional Development

There are a variety of approaches to professional development for informal science and engineering activity leaders. The approach you choose depends on several important considerations, such as the experience and background of the staff, the context in which they are presenting the program, the time available for training sessions, and the specific goals for implementing these activities with youth. This section of the manual outlines some of these issues and the ways in which they can be addressed. We strongly suggest that part of the planning process for working with out-of-school program providers involve careful deliberation about how you will deal with such concerns.

In addition, we recommend basing the sessions with participants on published effective science and engineering activities, which should be used to model the activities that they will lead with children. However, we have included several sample outlines for various workshop formats to provide a starting point that can be modified to suit your particular circumstances.

<B>About Our Approach to Professional Development

At first look, it may appear that professional development of educators in out-of-school environments would be very different from working with teachers in a school-based context. Of course there are special considerations to be made given the differing goals for out-of-school programming versus the in-school curriculum. However, there is much that can be transferred and applied to the out-of-school field from our experience with in-school professional development efforts. To that end, we have assembled a set of suggested activities that can be used flexibly in constructing professional development programs for out-of-school activity leaders that are based on widely recognized best practices in professional development. You will find that the types and structure of the training activities are somewhat similar to that which happens in the professional development of teachers in a more formal setting, but they are adapted for working with the out-of-school audience.

<B>Considering Your Audience

Whether you are training your own staff or are providing professional development for a local CBO, it is critical to first answer some questions about the experience and expectations of your audience. Have they ever led science or engineering activities with children? Will they be directly leading the activities with children or will they train others to do so? Have they had positive experiences with science and engineering in or out of school? What are they expecting to walk away with after the session? How exactly will they be implementing science and engineering activities into their existing program?

It is safe to assume that the activity leaders you are working with will have a wide range of experience, skills, and familiarity with the science and engineering content knowledge. Your design for professional development will need to take into account this diversity of skills and content knowledge background, especially when it comes to the implementation of hands-on science and engineering activities. Adults working in out-of-school programs come to this work from varying backgrounds. Many are college students who are interested in working with youth, some may come from a recreation background, but usually only a few come prepared through training in teaching. Typically, they have little or no experience leading science or engineering activities with children.

If the group of adults you are working with is indeed new to science and engineering, you will want to make sure that they have positive and successful experiences with the science-and-engineering-activities sessions that you are presenting. They will be more inclined to lead these types of activities if they can directly see their value for children. Another reason that we suggest enacting the curriculum pieces with the adult leaders is providing familiarity with the processes the children encounter as they do the activities, as well as modeling effective activity leading techniques. It is also important to stress that an extensive science or engineering background is not necessary in order to successfully lead these types of activities with youth. One of the main goals for this type of professional development is to motivate the participants to take on the challenge of leading hands-on inquiry-based activities while feeling supported through learning about successful techniques for conducting activities and handling various kinds of implementation issues.

<B>Context Considerations for Professional Development

It is worth considering the level of engagement of the CBOs represented by the activity leaders. Some agencies may just be getting acquainted with the nature of science and engineering activities and so may only be offering these types of activities on an occasional basis. Other agencies and programs may have already made a strong commitment to offering science and engineering activities on a regular basis and may be engaging youth in science and engineering activities as often as twice a week during the school year. The professional development activities and curricula highlighted in this manual are primarily designed to address the needs and concerns of those agencies that have made a strong commitment to offering science and engineering activities as a core part of their program, as this was the focus of our program. However, we anticipate that many of the same presentations can be used to build awareness of the value of these types of activities with children and youth, and can encourage programs new to doing science and engineering to consider including them in their programs.

It is also useful to get a sense of the challenges activity leaders may encounter in attempting to carry out science activities on a regular basis, as well as the goals of the administrators who plan the out-of-school program. In the current climate of rising academic expectations, out-of-school programming administrators are facing increasing pressure to offer activities that will help to make out-of-school time more educational. Priorities for particular types of activities may shift due to funding or to the interests of parents and youth. The physical setting available for doing science and engineering programming may involve sharing space with other ongoing activities or presenting activities in an open room full of distractions. These limitations should be kept in mind when considering what activity leaders can accomplish in this kind of environment. Time should be allotted during the professional development for discussing these issues.

<B>Organizing Time for Professional Development

Current research shows that short-term professional development—sometimes known as one-shot workshops—does not have a lasting effect on teachers' practice and this would also seem to apply to those who work with children in informal settings. Through our work with out-of-school activity leaders, we found that participants benefited from receiving sustained professional development over the course of one year or more. For example, the preparation and support for those involved in implementing science and engineering activities might begin with an extended workshop session, say for two to three days, and subsequently include monthly meetings and additional training sessions to introduce new topics. It is also possible to provide more specific coaching sessions for individuals by making site visits to directly observe activity leaders and answer any ongoing questions.

Obviously, this is a rather luxurious model of professional development and assumes access to considerable resources and time for professional development sessions. Here we have provided outlines for several different types of training programs as well as some optional presentation scripts designed to introduce specific strategies to activity leaders or to foster discussions about implementation issues. Depending on the time available for training, these can be thoughtfully assembled by combining various pieces into an effective professional development program for out-of-school activity leaders.

<B>Types or Models of Professional Development

The type of professional development you carry out will depend on the amount of funding you can access and the availability of activity leaders. In this section, we offer ideas on how to carry out the following institute options:

- One three-day institute during the summer or early fall with some follow-up meetings during the school year.
- One two-day institute during the summer or early fall with one-day institutes once every two months.
- Multi-day institutes, with days spread out during the school year.
- Monthly meetings of three-hour duration during the school year.

Generally, the types of institutes suggested below comprise three types of activities.

1. Direct engagement with a project, investigation, or problem through hands-on experiences or active, collaborative discussions and problem solving.
2. These are followed by reporting about the experiences and a processing of these experience in terms of helping participants understand the goals and content of the project as well as related implementation issues.
3. A third part is a structured reflection on these experiences with the purpose of deepening participants' understanding of content knowledge about the processes of science and

engineering as well as basic pedagogical practices.

The type of professional development that you choose to carry out will depend on the amount of funding available to you as well as your availability to the activity leaders.

<C>Option 1: Three-Day Institute

DAY 1

Participants are introduced to a problem or phenomenon as suggested in a published curriculum unit. They explore this problem in a hands-on or active manner in small groups, acting in the role of adult learners. A follow-up discussion happens where they report on their experiences. This discussion includes some processing for meaning while implementation issues regarding this specific project are held off until most of the activities have been completed toward the end of the day.

A second activity is introduced from the published curriculum unit. The participants explore, report, and discuss as happened in the first activity.

A third activity is carried out in a similar manner as the first two.

The remaining activities of the unit are divided up among the group of participants. They read the unit to get a sense of what constitutes these activities. They enact what is suggested in the unit to get a feeling for what is involved and how these are related to the preceding activities. Each group reports to all of the participants what was involved in their activity.

An extended discussion is then carried out that has the participants step back from the activities and reflect on their experiences. It is also the time to discuss how the activities from this specific project can be implemented back in their settings. The facilitator can propose the following questions to help the participants get started.

- What did you learn from the activities?
- What questions do you have about the purpose of the activities?
- What concerns and implementation issues do you have about the activities?
- What kind of background knowledge would you need to carry out the activities?

A sequenced process is recommended for preparing for and carrying out the discussion.

1. Have participants reflect on their experience by writing some notes for a few minutes.
2. Have participants discuss their thoughts with the group they have worked with for 5 to 10 minutes.
3. Carry out a whole-group discussion of the response to these and other questions they have.

In the process of carrying out this whole-group discussion, you can challenge the participants to draw upon their own previous experiences and knowledge to answer the questions that come up. (The goal here is for participants to come to the realization that they are a community of learners who can share their knowledge and skills.)

When participants are hesitant or lacking the background, then the facilitator can provide advice. The facilitator should spend some time during this discussion having the participants make a quick review of the activity (curriculum) guide to help them realize that they should read it very carefully. It should provide answers to some of their questions. Activity leaders are strongly urged to use the activity guides in a conscientious manner.

Note: At this point the focus is still on the specific project. Facilitator should be modeling pedagogical practices. A discussion about these practices as they were modeled during the activities would be carried out on Day 3.

DAY 2

The same kind of structure and set of activities and discussions can be carried out during this second day. Start by introducing a different project. This should be one that has similarities to the first project but provides a context for bringing up implementation issues different from the previous project. For instance, some projects involve hands-on activities that can be potentially very messy or have safety issues. “Cake Chemistry” from *Explore It!* and “Ooblech” from *GEMS* are two examples. A messy project can be done on the first day. Projects having safety issues such as “Dry Ice” from *GEMS* and “Heating a House and an Oven” from *Explore It!* could be done on the second day.

DAY 3

This day can be spent having participants engage in activities and discussions that help them think more deeply about the purpose of the activities and about ways of dealing with implementation issues they will encounter when carrying out the activities with children or youth.

(Part 3 of this manual has several different follow-up activities that can help participants develop a deeper understanding of ways of implementing curriculum.)

There are more suggestions than can be carried out over a full day. Depending on the goals of your institute and the background and experience of your participants, you can choose those you feel will be most helpful and are best related to the projects of the previous two days.

<C>Option 2: Two-Day Institute

If it is not possible to have a three-day institute, then a two-day institute could be planned. In this option, you would follow the Three-Day option, but remove the second day of the institute. Thus
Day 1 of two-day = Day 1 of three-day
Day 2 of two-day = Day 3 of three-day

<C>Option 3: Multiple-Day Institutes Over an Extended Time Period

Multiple-day institutes over an extended period of time might mean using the two- or three-day institute models above, but using a number of different projects from the same or different curriculum programs. This could take the form of a two day institute in early September, another 2 days institute in December and possibly a third two day institute in March. The benefit of this option is that the extended time period with the same participants gives them an opportunity to use what they've learned in an earlier institute at their out-of-school programs, and then to return to a later institute to share with other program leaders, building a community of learners and extending their ability to implement these type of activities.

In this option, you need to think about the choice of each of the different curriculum units. One approach is to start off with a project that is relatively easy for activity leaders to implement and feedback from the field indicates that the project is highly engaging of children or youth. Another approach is to pick curriculum units that present different kinds of implementation issues such as mentioned above. One could involve messy activities; one could involve safety issues; or one could involve the need to carry out the activities in a large space such as the testing of model vehicles.

<C>Option 4: Monthly Meetings During the School Year

This type of involvement provides a means to introduce multiple projects and build a community of learners. It also provides time to address multiple implementation issues. However, these types of meetings would have to be only a few hours thereby limiting how deeply you can go into the substance of the activities and implementation issues.

<A>Selecting a Curriculum Unit and Preparing for the Presentation of an Out-of-School Project

The goal of our approach to professional development is to acquaint the activity leaders with a curriculum unit that they can implement in their program. More importantly, the goal of the institute(s) is to help activity leaders adopt new pedagogical practices, reflect on their own practices, and make the move toward implementing the curriculum unit in the spirit of becoming a more professional practitioner. We propose that you use a specific published curriculum unit as a way to introduce and discuss basic pedagogical practices. The participants are actively involved in the activities from one unit, and they are presented in a manner such that the participants function in the role as both adult learners and students. Participants are encouraged to come up with their own questions or problems, and to find or design ways to answers them. The activity's structure goes from introduction to activity to reporting on discoveries to processing or making sense of discoveries. As much as possible, the presenter's role models the pedagogical practices that will be discussed.. In this manner a specific context, the one unit, is the means to illustrate and discuss practical implementation issues.

Selecting the Curriculum Unit

When selecting a curriculum unit to present as a model for implementation, you need to consider both practical and professional development issues:

- Is the project (set of explorations or design challenge) representative of other kinds of projects so that it can act as a model for implementing science and engineering activities?
- Do the activities provide opportunities to model and discuss a range of pedagogical practices?
- Is the project one that can be implemented by activity leaders having a wide range of skills and content knowledge?
- Can two or three of the activities of the project be done during the institute in a thorough manner so that participants have an opportunity to get a "real feel" for the project?

- Are the materials to implement the project relatively inexpensive, relatively available by way of local purchase or from a science supply business?
- Does the project encourage and foster critical-thinking skills useful to carry out inquiry in the school context?
- Are the activities highly engaging for both their intended youth audience and for the institute adult participants?
- Are the activities age-appropriate for the intended audience?

There are now a wide variety of published curricula and kits that have been designed for the out-of school environment. These are of varying quality and practicality. To get a sense of what is available and their relative quality, view the links below.
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Ideally, you should be familiar with the activities and have experience presenting them prior to the institute. So, it is advisable to obtain the curriculum well ahead of the institute, and do some or all of the activities on your own or with children. Also, it can be useful to talk with those who have implemented the activities with children or youth to get a sense of what may be special issues associated with the particular unit. Below we introduce three curriculum programs, along with selected activities in the programs, that you may choose to use in your institutes: *Design It!*, *Explore It!*, and *GEMS*.

<C>Design It!

The "**Balls and Tracks**" set of activities from *Design It!* (developed by Education Development Center, Inc., and published by Kelvin) can be an exciting introduction to design challenges. A limited set of materials is needed and constructing a functioning arrangement can happen fairly quickly. Children and youth find the activities challenging and fun.

"**Paper Bridges**" or "**Gliders**" are also relatively easy to present in an institute since the materials are simple and quick results are obtained.

"**Balloon-Powered Cars**" and "**Rubber Band-Powered Cars**" use relatively simple materials, and results can be quickly happen. However, these projects work best if they are implemented after activity leaders and children have had some previous experience with design projects. It takes some skill on the part of the activity leader to help children move forward in a productive manner without providing too much direction.

<C>Explore It!

Explore It! (developed by Education Development Center, Inc., and published by Kelvin)offers a range of projects, each requiring different levels of skill and background to implement, both in an institute and with children at an out-of-school program site. Some of the projects have special material management considerations, such as the use of water or messy materials, while others involve the need to work in a large space, such as when testing paper airplanes or model cars. You will need to consider balancing excitement and engagement of the activities with the accompanying challenges of handling materials or special space requirements.

The activities in "**Bubbles**" are simple and very engaging for adults and children alike, but working with bubbles means dealing with soapy solutions on tabletops. Some activity leaders may find the activities so engaging that they are willing to tolerate the potential messiness (some solutions to this issue are offered in the guide). This series of activities has been successful in getting activity leaders excited about implementing exploratory science activities. The sequence of activities represents a model of a progression that can illustrate how an exploration of a phenomenon can be sustained over multiple sessions.

The activities in "**Soda Science**" are also simple and very engaging. Fruit juices can be the focus of designing recipes for drinks, and one of the challenges could be to minimize the amount of sugar while making the drink palatable. This unit also provides opportunities to use math in practical ways, such as in ratios and proportionality.

Two *Explore It?* projects, "**Balancing Toys**" and "**Colliding Balls**" have videos associated with them. These videos provide the opportunity to have participants see how the exploration can take place with children and are a way bring up implementation issues and pedagogical practices. The videos are best presented after the participants have experienced some of the activities in these projects.

<C>GEMS (Great Explorations in Math and Science) Curriculum

The activities in the GEMS "**Oobleck**" unit (developed and published by the Lawrence Hall of Science) revolve around an intriguing substance made of cornstarch, food coloring, and water. Participants learn about properties as they explore and discuss the substance. They also learn how to apply those properties to technology, as they design spacecraft to land on the substance. Engagement is very high. There is the potential for messiness with "Oobleck", but suggestions for controlling the mess are included.

Participants taking part in the "**Crime Lab Chemistry**" unit learn about the forensic techniques of chromatography and fingerprinting and use them to solve made-up mysteries. Materials management is relatively easy with this unit, and engagement is high.

<B>Planning for a Presentation: Explore It!

Although all of the above programs are excellent choices to use in professional development, below we go into more detail about using the *Explore It!* program, specifically, the activity "Balancing Toys." We chose this activity to explore more deeply because of the available videos showing this project being implemented in an out-of-school situation. After doing some of the activities, participants can use the video to help in their discussions of implementation issues.

Implementation

The "Balancing Toys" curriculum guide presents instructions for eight activities. There are two parts to this project. Part 1 includes four kinds of "toys" or models to be built using the plastic from a pool noodle and pieces of cardboard. The plastic of the pool noodle is used in three of these models while pieces of cardboard are added to transform the plastic into a person, boat or plane. Part 2 has suggestions for making different kinds of mobiles using dowels, string, fasteners, and cardboard. We suggest that you do the first activity and either the boat or plane as the second activity, allotting about 45 minutes for each. Participants should have enough time to first explore on their own what can be done with the models, then to manipulate the models to find answers to challenges offered in the activity, and then to have a discussion about the results. What happens next depends on the amount of time you have for the institute and how far you need to go to give the participants a sense of the overall project.

If you have several more hours allotted, you can do two activities from the mobile section. If you have only one more hour allotted for activities, you can have different groups do some of the remaining activities working directly from the pages of the curriculum guide. In either situation, enough time should be allotted to process each of the activities and have a follow-up higher-level discussion about the purpose of the activities and about any implementation issues participants had or foresee at their own sites.

Discussion

Here are some questions you can use to start the discussion.

What is the educational value of focusing on a single phenomenon with a limited set of materials?

Some novice activity leaders may have the concern that all of the activities are about balancing. Will the children become bored or uninterested after the second or third activity? They may if time is not taken after each activity for children to share their discoveries and talk about what they have discovered. You can point out that there is a great educational value for having a sequence of activities that build on each other and focus on a single phenomenon, such as balancing.

How can you adjust the introduction of the materials and the suggested activities for the kind of children the participants are working with?

The guide was written for reaching a wide range of users. Some may be experts while other are novices at doing science activities for children. Several of the activities have Explorer's Sheets that give specific suggestions for what can be done with the models or mobiles. Depending on the expertise of the activity leader and the experience and skill level of the children, the Explorers' Sheets may or may not be introduced. For the novice working with inexperienced children, it is advisable that the sheet be introduced and followed. On the other hand, the experienced and confident activity leader could introduce each of the models and challenge children in an open-ended way to find different ways that they could balance these models using the pieces of cardboard and nails. At times, this kind of activity leader could suggest manipulations to the models that were given on the Explorers' Sheet but without actually introducing the sheet. Not using the Explorers' Sheet is a much more challenging way of doing the activities for both activity leader and children. It does, however, give each activity leader more freedom to explore, but the danger is that the children will become frustrated and bored. They may begin to feel overwhelmed by possibilities and soon give up.

Is there any logic to the way the activities have been sequenced?

It has been found in the implementation of *Explore It!* materials that activity leaders tend to skip around in the curriculum guide, choosing activities arbitrarily. Having a discussion about the sequence of the activities can help participants see the importance of following the sequence.

For some, following the activities sequentially may be readily apparent while, for others, the guide may be just a collection of activities around the general theme of balancing. You can point out that starting off with a model of a human body in Exploration 1 is a way of helping children relate the activities to their own personal experience. In many sports activities and in dancing, keeping your body balanced is part of being a good performer. How the body is balanced during these activities is usually done without awareness. This first activity is an opportunity to think more carefully of how arranging the arms and legs can put the body in a balanced or unbalanced position. Following up this activity with the model boat allows the children to go further in the process of beginning to isolate what factors are important to keep things balanced vertically. The model airplane is about finding out what is important in keeping things balanced horizontally and is a chance to see if the same discoveries apply to a horizontal orientation. Balancing the acrobat is a way to begin to apply what was discovered in the three previous activities.

The mobiles activities in the second half of "Balancing Toys" deal with balancing in a more simplified manner in the sense that one can see how changing weights or position seem to be the most important factors determining how things balance. Children will use what they've already learned in the first half to take a step back and look again at weight and position. The last activity in the guide, working with a simple balance, is a way of further applying what has been learned in all the previous activities and developing some simple principles that are related to basic concepts in physical science.

<A>Modeling Pedagogical Practices

One of the professional development principles that we adhere to, as much as possible, is to introduce pedagogical practices in context through modeling with the participants as opposed to presenting these ideas as a disembodied set of practices and principles. In other words, we don't just talk about how to effectively lead science and engineering activities; we do it *with* the participants in a workshop setting. Modeling how to lead the activities is much more convincing and effective than merely telling participants what to do when implementing activities with children and youth. For example, when exploring a particular set of activities or curricula, participants should first experience the activities as adult learners and actually try them out for themselves. By experiencing the activities in this way, participants learn about possible pitfalls and struggles children may encounter, but more importantly, this allows for an in-depth discussion of the strategies involved in leading high-quality learning experiences with children. The concrete experience with a given set of materials provides a model for how to structure and present activities in order to provide the greatest impact on learners.

However, modeling alone is not sufficient for participants to become aware of, recognize, and begin to emulate effective educational practices. Throughout any type of professional development program, there needs to be adequate time given for reflection about the rationale behind the practices and strategies that are modeled, as well as the opportunity to apply the demonstrated principles to the context where participants will be using them. This type of reflective exercise is essential to help participants adopt these pedagogical strategies into their own practice. We provide some examples for how such reflections can be structured for participants, and encourage professional developers to allow time for processing the experiences in terms of how they relate to science and engineering content and practices, as well as discussing commonly encountered implementation issues. There are a variety of scripted presentations to select from based on the needs of your activity leaders and the emphasis for your professional development program.

In general, the institute formats suggested here include three types of professional development activities. We feel that any length of institute should include these essential pieces:
1) **Direct engagement** with a set of activities, an investigation, or a challenge through hands-on experiences and through active, collaborative discussions.
2) **Reporting** about learning experiences and reflecting on process skills and specific content explored in the activity, deepening participants understanding of content knowledge and the processes of science and engineering.
3) A structured **reflection** about how the experiences were modeled, the rationale for effective pedagogical practices and discussion of related implementation issues.

List of Possible Strategies to Model

Based on what you know about the experience and background of your audience, decide which particular pedagogical practices would be most useful to model and discuss. Ideally, all these tips should be modeled with participants; however, the list can be overwhelming to those new to training activity leaders. We suggest the following important practices for activity leaders to be aware of and utilize during the implementation of activities. It will be helpful to read through all these and select a few to focus on…especially if you're working with same group of participants.

Introduction Techniques:

- Providing a context for each of the activities.
- Using a hook to engage children and youth in the subject at the beginning of the lesson.
- Relating the current activity to previous ones-building on what was learned.
- Encouraging children and youth to think about how the topic applies to situations in their lives.

Management Strategies:

- Forming children and youth into teams and assigning roles; working in cooperative groups.
- Setting a respectful tone.
- Creating an atmosphere where exploration is encouraged, and children and youth feel comfortable discussing ideas.
- Conducting discussions away from the distraction of materials.
- Utilizing whiteboards and/or large sheets of paper to record observations.
- Utilizing drawings and other graphic representations.
- Employing hand raising or hand signals to ensure whole-group involvement.
- Making sure materials are well organized before class, and distributing them in a planned manner.

Role of the Activity Leader:

- Being an active observer during the activities.
- Helping children and youth make sense of and process what happened during their explorations.
- Considering your role as teacher to be a collaborator with the children and youth, trying to figure things out together.
- Providing a chance for children and youth to figure things out for themselves, rather than telling them the answer.

- If children and youth give responses including science terms, asking them to explain what they mean by those terms.

Discussion-Leading Strategies:

- Having children and youth report their discoveries.
- Asking broad questions (questions that do not have one correct response but, rather, have many possible responses) to encourage participation and higher-level thinking.
- Using focused questions sparingly (questions that do have one correct response) to recall specific information.
- Using wait time (pause for three seconds after asking a question before calling on a children and youth).
- Giving nonjudgmental responses, even to seemingly outlandish ideas or amazingly astute ideas.
- Listening to children's and youths' responses respectfully, and asking what their evidence is for their explanations.
- Asking other children and youth for alternative opinions or ideas.
- Trying to call on as many females as males.
- Trying to include the whole group in the discussion.
- Offering safe questions to shy children and youth.

Meaning-Making or Follow-Up Techniques

- Setting aside time for thoughtful discussion after activities, and keeping the discussions interesting.
- Encouraging children and youth to reflect on what they have learned at the end of an activity or project.
- When children and youth share an idea, asking follow-up questions to probe what they are thinking
- Not introducing scientific terms until after children and youth have had a chance to explore and wonder about the topic.

PART 3
Follow-up Activities

Part 2 gave suggestions on how to introduce participants to a specific curriculum unit as a model for carrying out activities. It also suggested that you "practice what you preach" by consciously modeling different practices so that participants could observe how they happen in the implementation of the activities. And it focused on the *doing* of the activities, but talked about having preliminary discussions about the activities' purpose and how to carry them out with children or youth.

This next section provides suggestions for helping participants reflect on these experiences and go beyond the activities to think about how they relate to science and engineering content and practices; for presenting an extended set of activities and discussion to help participants focus on specific pedagogical practices; and for how they can work on incorporating them into their own work with children.

Discussing Implementation Issues

In a previous section, it was suggested that you make a conscious effort to act as a role model when having participants become acquainted with the activities of a specific project or curriculum. It was also suggested that you take time to have participants reflect on the manner in which the activities were carried out, giving particular attention to specific pedagogical practices. One way of starting off this discussion is to have participants report on what they noticed about the way you carried out the activities. What moves and directions did you give that they thought helped structure the activity?

This discussion can be an introduction to an extended discussion about pedagogical practices and implementation strategies. The specific context of the activities is a way of making these practices relevant. The goal is to get the participants thinking of the practices as ones that are utilized in all or most of the activities that they do.

Always keep in mind that the activities take place in an informal context and that situations probably vary greatly in terms of programming and organizational culture. Here are some questions for potential discussion:

Set-up
- How can an activity leader engage children's interest at the beginning of a project?
- Should there be some basic rules for appropriate behavior?
- How do you establish routines that help make children comfortable with what is appropriate participation?
- How do you plan for and set up situations for effective material management?

Teamwork
- Should you and how do you have children work in teams?
- How do you handle children who have problems working in teams?
- Should you and how do you get children to take on roles in their teams?

The Activity leader's Role

- What role do you assume when children are doing the activities?
- When and how should instructors intervene in children's explorations?
- What kinds of questions do you ask children with these kinds of activities?
- Should questions vary depending on when they are asked?
- How can you get children to be responsible for clean up?

Reporting and Reflection

- How can you lead a successful discussion with children?
- How do you get children comfortable reporting on their experiences?
- How do you get children comfortable making sense and reflecting on their experiences?
- When and how should content be introduced by the activity leader?
- How can interest be sustained throughout a project?

It is a useful strategy when asking these questions to first solicit from the participants what ways they have dealt with these issues. Particularly if there is a diverse background of participants, some can provide useful and relevant advice for the whole group. Having this advice come from the participants promotes the concept of a community of learners and gives a greater legitimacy to this advice, since it is coming from a practitioner working in "real situations." You can also give your own recommendations based on what is considered effective practice from experts in the field.

Given that you are having this discussion within the context of one project, all of these questions may not be relevant. Also, attempting to deal with all of these questions at once can be very daunting for the participants. A practical approach is to spend time on several of these issues only, giving attention to those that the participants feel are most in need of addressing. If there is a possibility of multiple institute days/times, you can plan to address a few of these issues at a time, eventually getting at most of them over the duration of the professional development.

Using Videos in Workshops

Viewing videos of actual out-of-school activities with participants in a workshop or institute can be an effective way of discussing implementation issues. Since videos provide a specific context, it helps participants to anchor their thinking and can move them into a discussion about how to interpret what children are doing and how to deal with specific problems in the implementing of activities. It can move them toward becoming reflective activity leaders where they go beyond just the presenting of activities but are continually thinking about how their role and behavior can lead to more productive engagement with children and youth.

Ideally, you would use a combination of hands-on activities exploring a topic with a follow-up of viewing a video of the same topic in an actual setting. Alternatively, videos can be selected that present situations for discussing specific implementations issues. For instance, how to handle messy activities may come up in activities such as "Oobleck" (*GEMS*) or "Siphons" (*Explore It!*). Although videos showing the implementation of these specific activities are currently not available, you can use one showing the use of messy materials in another project to connect to a discussion about those messy materials used in the "Oobleck" and "Siphons" projects.

One approach to viewing videos is to present short segments of an extended video to the participants and ask them to discuss what they observe about the children's behavior and the moves of the activity leader. The extended video provides a sense of the context of the behaviors. You would select segments where behavior on the part of the children or activity leader provides a context for discussing implementation issues you wish to illustrate and discuss.

The goal is for the participants to develop their ability to observe children's behavior and for them to think about what is happening as it may relate to their own practices. This can be done by discussing how the activity leader handled the situation in the video. The purpose is not to make judgments about the role and moves of the activity leader but, rather, to provide concrete situations where participants can discuss and reflect upon specific ways of implementing activities.

There are many videos of classroom situations that are available. Which you use depends on what specific implementation issues you are focusing on and whether similar ones occur in the out-of-school context on the video. However, many of these videos are highly edited with a voiceover. They do not readily lend themselves to fostering discussion since the voiceover tells the viewer what is being illustrated. However, you can turn off the sound when there is narration, letting the viewers make their own judgments about what they are seeing.

Those videos of activities in informal settings with no voiceover and little to no editing are most suitable for promoting reflective discussions.

To make the best use of the videos, it is essential to view them beforehand and to select those segments that you think best match the issues you want to discuss.

Framework for Viewing Videos

When showing videos to participants, it can help the viewers if you could help them focus on specific types of behavior. Attention can be given to what the children are doing or what the activity leader is doing. If they want to practice as a group learning how to interpret what children are doing, then they can give their full attention to the behavior of the children. For instance, during explorations some activity leaders are not sure if the children are engaged in a productive manner because of the more open-ended nature of this type of activity. Participants can view segments of a video and discuss what they have observed in terms of whether the behavior of the children was productive or not, and what they think the children may be learning. If they want to discuss ways of how to handle different kinds of situations with children, then the focus can be on the behavior of the activity leader. One way of doing this it to discuss with them before the viewing what specific implementation issues they want to discuss. After the viewing of a segment they can discuss what the activity leader did and whether a different move by the activity leader would have made a difference in effecting the involvement of the children.

To focus on specific types of behavior by the children or the activity leader, you can use the following framework. It is structured around the phases of an activity and separated into behavior of the children or youth and the behavior of the activity of the leader.

- During the explorations
- During the reporting of what was discovered during the explorations
- During the processing or making sense of the explorations

During the explorations

Behavior of Children or Youth

This category focuses on those times when children and youth are directly engaged with materials.

- To what extent are the children focused or unfocused on the posed problem and materials?
- Is their involvement sustained over multiple minutes or is it brief and sporadic?
- Do they appear to be testing the materials (repeating same manipulations multiple times) to see if they get interesting and repeatable results?
- Do they set up informal experiments, attempting to determine what may be the cause of some special result?
- Do they spontaneously generate questions?

Behavior of Activity Leader

- Is the activity leader involved with children in a useful manner?
- Does the activity leader provide timely support to the children when needed?
- Does the activity leader moderate unproductive interactions between members of a team?

During the reporting of exploration discoveries

Behavior of Children or Youth

- Do they report in a coherent manner?
- Are they fully responding to the activity leader's comments or questions?
- Do children or youth use gestures to convey what they have observed?
- Do they use sketches or simple drawings of what they have observed?

Behavior of Activity Leader

- Does the activity leader have children set aside materials?
- Does the activity leader provide time for children to report?
- Does the activity leader have children evaluate their reporting of results?
- Does the activity leader use drawings to facilitate the reporting?

During the processing or making-sense phase of the explorations

Behavior of Children or Youth

- Are they willing to make guesses or develop explanations of what they have observed?
- Do they make connections to prior experiences?
- Do they back up their explanations with observations or results from their informal experiments?

Behavior of the Activity Leader

- Does the activity leader take time for children to discuss their discoveries or results?
- Does the activity leader encourage children or youth to come up with simple explanations?
- Does the activity leader encourage children to make connections to previous activities and experiences from the daily life?

- Does the activity leader use drawings or sketches to help the children or youth to clarify observations and results?

Using the Framework for Viewing the Videos

Before the Workshop

1. Decide on what video would be useful and appropriate for showing the participants in the workshop.
2. View the whole video, taking notes on segments you think are most relevant to the goals of your workshop.
3. Use the framework to get suggestions of questions you might ask the participants.
4. Make copies of the framework for each participant.

During the Workshop

Introducing the video would be best after participants have been involved with the materials and have spent time reporting and processed their own results.

1. Tell the participants that you will be showing them a video of an activity in an out-of-school situation. The video will be used to have a discussion about how activities from a curriculum can be implemented. Since many observations could take place when viewing a video, tell participants that together you need to focus on a particular part of an activity or particular practices.
2. Hand out the framework and have the participants discuss in small groups what phase and what questions they want to focus on. Have each group report on what they have decided and why.
3. Show the video segment.
4. Have each group discuss among themselves their observations and reflections about the video.
5. Have a whole-group discussion where each group shares their observations and reflections.

Depending on the time you have available, several segments could be viewed and discussed in this manner. At the end of this process you can have participants reflect on the overall experience and ask them to how it may affect how they will change their own practice.

Reflecting on the Nature of Science

Activity leaders gain insight into the nature of science by *doing* science and by *reflecting* on it. This experience provides a sense of the actual processes involved in science and helps communicate the nature of science as an evidence-driven human endeavor to investigate, find out about, understand, and make generalizations about the natural world.

Science is a marvelous, fruitful, and constantly changing way of looking at the world. It is based on evidence, testability, consistency, non-dogmatic objectivity, and peer review. Like many other systems of thought, science is a quest for truth, yet one of its greatest strengths is that it never claims to have arrived at the truth. It helps us to understand the world around us, and in a practical sense, it has great predictive value. Some people think science is infallible. Others see it as arrogant, biased, or heartless. It is none of these things.

Science is an extremely valuable way of knowing. Through attempting to define science, we gain an understanding of its strengths and pitfalls. We take a critical look at what often passes for science, but on closer examination does not stand up to evidence-based scrutiny. These misinterpretations, conscious and unconscious, are widespread, and examining them can help hone our own understanding of what science is and is not.

After an introductory brainstorm about "What is science?" participants take part in a science inquiry activity. The *GEMS* (Great Explorations in Math and Science) out of school activity guide "Oobleck" is highly recommended, but other science inquiry activities may be substituted. In the "Oobleck" activity, participants investigate a strange substance called Oobleck and then seek, using the evidence they've gathered, to make some generalizations about the substance. They design tests to investigate whether Oobleck is a solid or liquid, and share their findings. This experience provides a sense of the actual processes involved in science and helps communicate the nature of science as an evidence-driven human endeavor to investigate, find out about, understand, and make generalizations about the natural world.

Many activity leaders will have had limited exposure to science, and it's likely that much of the science education they may have received did not reflect the true nature of science. Understanding the nature of science is important not only for children and youth, but for anyone who leads science activities. Yet many adults, as well as children and youth, hold misconceptions about what science is. As such, this activity represents an important early experience for anyone who leads science-related activities. Not all of us learned science in this way. And yet science can be introduced to the youngest of children or youth in ways that engage them in the firsthand collection and evaluation of evidence, reflecting the nature of science. When an activity leader grasps and appreciates the nature of science, he or she can truly embrace the process of science teaching that is advocated in the *National Science Education Standards* and taught through all the science education activities recommended in this manual.

Session Objectives

In this session, participants deepen their understanding of the nature and practices of science through gaining an appreciation of the following points:

- Scientists use a wide range of inquiry methods as they inquire about the natural world.
- Science is based on observations and hypotheses within a testable framework of ideas.
- Scientific results must usually be replicated (or accepted as replicable) in order for the findings to be seen as valid.
- Science is a collaborative enterprise.
- Scientific knowledge evolves over time as the community of scientists inquire in different and deeper ways to uncover new evidence that changes and/or refines the accepted understanding of the natural world.
- Non-scientific ideas are sometimes presented as scientific to the general public.

Session Activities At a Glance

Total Time: 2 hours (if science inquiry activity can be done in one hour)

What Is Science? (35 minutes)

This session begins with a "Thought Swap," in which participants in rotating pairs are challenged to categorize statements as:

- Scientific
- Not scientific
- Not scientific, but appears scientific

For each statement, participants discuss the criteria they used to classify the statement and look for larger patterns in the categories they create. The statements provided range from scientific and pseudo-scientific to poetic and religious, and some are easier to classify than others. Participants' exact choices of which statement belongs in which group are not as important as the discussion of what makes a statement scientific. (Controversy, after all, is also the stuff of science.) In a facilitator-led large-group discussion, the group generates lists of what makes a statement scientific, not scientific or not scientific, but appears scientific.

The facilitator now introduces the following slides (via overhead transparencies or Powerpoint and LCD projector):

- Slide 1: A Few Perspectives on Science <add links to slides?>
- Slide 2: Science is…
- Slide 3: Science is not…
- Slide 4: Terms Used in Describing the Nature of Science

Inquiry Science Activity (time variable)

Participants take part in an inquiry science activity appropriate for out-of-school children or youth. Through participating in the activity, participants get a firsthand experience of scientific inquiry. They also are exposed to an activity appropriate for teaching the nature of science to children or youth. The *GEMS* (Great Explorations in Math and Science) out-of-school unit "Oobleck" is highly recommended, but other inquiry science activities may also be substituted.

Concluding the Session (20 minutes)

How We Acted Like Scientists

After the activity, participants brainstorm a list of how they acted like scientists, applying what they have learned about the nature of science earlier in the session to their own scientific pursuits.

Summary of Session

Participants brainstorm pitfalls and stumbling blocks of science. The facilitator introduces the slide Summary for Session.

What You Need for the Whole Session

For the "What is Science?" activity

For each group of 4-6 participants:
What is Science? activity sheet: Scientific Statements

For the whole group:

- Slide 1: A Few Perspectives on Science
- Slide 2: Science is…
- Slide 3: Science is not…
- Slide 4: Terms Used in Describing the Nature of Science
- Slide 5: Summary of Session
- Overhead Projector or LCD Projector and Computer with Powerpoint

For the science inquiry activity

Whatever materials are necessary for the activity you have selected

For the Session Summary

For the whole group:

- Handout 1: Science is/Science is not…
- Handout 2: Terms Used in Describing the Nature of Science

Getting Ready

For the "What is Science?" activity

Duplicate Scientific Statements. Make enough copies of What is science? activity sheet: Scientific Statements for each group of four to six participants to have one copy. Cut each page into individual statements (1 statement/strip).

For the science inquiry activity

Whatever preparation is necessary for the activity you have selected.

What Is Science? (35 minutes)

Introduction

1. **Introduce public ideas about scientists and science.** Tell participants that the image of a scientist (whether positive or negative) has a certain mystique and aura, much of which may be fantasy, and some of which is accurate. Young children or youth often enjoy wearing the

trappings of stereotypical science, such as goggles and lab coats, and doing activities that make them feel "scientific." Similarly, non-scientists sometimes dress up their ideas in the trappings of science in order to tap into its mystique. This can create confusion for the general public about what science is and what it is not.

2. **Explain the rationale for the session.** Tell participants that if they are going to be leading science activities, it is extremely worthwhile to spend some time thinking about the nature of science and how this can be communicated to the public.

Thought Swap

1. **Introduce the Thought Swap.** Tell participants they will get a chance to talk with different classmates. They will be discussing a series of questions in order to think about the session's topic—the nature and practices of science.
2. **Line up participants.** Have participants stand shoulder to shoulder to form two parallel lines, so each person is facing a partner. Participants standing side by side should be at least 6 inches apart.
3. **Explain the procedure for discussing questions.** You will be posing a question for them to talk about with their partner facing them. They will have about a minute to talk. You will signal them to be quiet to prepare for the next question or statement by gently tapping on the shoulder of the first two participants at the end of the lines. These two will then pass the tap on down the line, till the entire group is quiet.
4. **Begin the Thought Swap.** Pose the first question for participants to discuss: **What is science?** Listen as partners discuss the question and encourage all to participate.
5. **Share responses with the group.** After about a minute, tap the first two participants at the end of the lines and wait for the entire group to become silent. Repeat the question, "What is science?" and ask a few participants to share with the large group what their partner told them.
6. **Change partners for discussion.** Tell participants that one of the lines will shift with each question, while the other remains in place. Have one of the lines now shift one position to the left so everyone is facing a new person—the person at the end of that line walks around to the beginning. Everyone now has a new partner.
7. **Discuss the next two questions.** Pose the questions listed below, shifting partners after each one. Pause after each question and ask a few participants to share with the large group what their partner told them..
   - What is not science?
   - When is something not science, but it appears scientific?
8. **Seat participants in small groups.** Ask participants to sit down with a group (creating groups of four to six), formed from those standing next to them in the Thought Swap lines.

Small-Group Discussion

> **NOTE**: Be sure to read through the "Concept Introduction: What is Science?" section of this activity before leading the following discussion.

Categorizing Statements

1. **Distribute statements to categorize.** Pass out a set of statement strips to each group of participants. Tell them that their challenge is to categorize the statements in one of three ways:
   - Scientific
   - Not scientific
   - Not scientific, but seems scientific
2. **Explain the purpose of the sorting activity.** Let participants know that exact "right" answers are not the point of the activity. The purpose is to create an opportunity to discuss and think about what science is and what it is not.
3. **Emphasize how to think about the criteria for sorting.** Let participants know that some statements will be fairly easy to categorize, but others will be challenging. Tell them that even with the relatively easy ones, they should discuss the criteria they are using to categorize them in a particular way.

Discussing the Statements

1. Discuss criteria for scientific statements. First, ask about the criteria that were used to place statements in the "scientific" category. Make a chart to record the groups' ideas on on your chalkboard, white board or chart paper, and title a column "What Is Science?" Encourage discussion and add the groups' ideas to the column.

> **NOTE**: You may want to refer to the possible responses noted in brackets below. These ideas are provided to help you guide the discussion. However, it should not prevent you from discussing any other comments that may come up in your session. The main purpose of this activity is not to discern the "right" or "wrong" answers, or resolve debatable issues, but to get participants thinking about the nature of science.

- Every human possesses a soul.
  [Not scientific, because not testable or verifiable. There is no way to show it to be false.]
- Water boils at 100 degrees Celsius and 1 atmosphere (atm) pressure.
  [Scientific, because it is testable and verifiable. There is a way to show it to be false.]
- Aliens from another planet built the Egyptian pyramids.
  [Not scientific, because not testable. There is no way to show it to be false.]
- People born under the astrological sign Aries are charismatic leaders.
  [Not scientific, because not testable. There is no way to show it to be false. The term "charismatic leader" is too vague and subjective to be tested; it depends on how it is defined.]
- All objects are attracted to other objects with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them.
  [Scientific explanation of gravity based on testable evidence. There is a way to show it to be false.]

- The Earth's surface is divided into many plates. The movements of these plates set in motion forces that result in earthquakes, volcanoes, and mountain building. The continents are embedded in these plates and are carried around by their movement.
  [Scientific explanation of plate tectonics based on testable evidence. There is a way to show it to be false. If a testable explanation is discovered that does not fit this theory, then the theory must change. The theory of plate tectonics, like evolution and relativity, provide a coherent, evidence-based, underlying explanation of many phenomena.]
- We hired scientists to test our product, and the results prove our product is better than that of our competition.
  [Could be considered scientific, or non-scientific and biased since the scientists were hired by the makers of the product. Science strives for objectivity.]
- If there is magic on this planet, it is contained in water. (from The Immense Journey, 1957)
  [Not scientific. Not testable; sounds too subjective. There is no way to show it to be false.]
- Mugwort is an antidote for poison oak. It can often be found growing near poison oak because nature often provides solutions for plants that may cause people problems.
  [Not scientific, even though parts could be testable. Nature does not plan for or think about the needs of humans.]
- The mind is a blank slate at birth. Whatever the child becomes is entirely a function of the experiences to which they are subjected as they grow.
  [Scientific or non-scientific. Could be a testable hypothesis. If it actually means to say that humans are not "hard-wired" for particular kinds of learning and behavior, then there is a large body of evidence refuting this hypothesis.]

2. Discuss criteria for non-scientific statements. Title a second column on your chart, "Not scientific."
Ask the group what criteria they used to categorize statements as "not scientific." Encourage discussion, and add their ideas to this column.
Note: this discussion will likely be more brief than the previous, since many of their criteria for non-scientific will simply be that a statement doesn't fit the criteria in the "scientific" category.

3. Discuss criteria for non-scientific statements that appear scientific. Add a third column to your chart, and title it, "Not scientific, but looks scientific." Ask what it is about some statements that made them look scientific, and then ask what made them reject them as not scientific. Encourage discussion, and add their ideas to this column.

Concept Introduction: What Is Science?

1. **Introduce contrasting perspectives on science.** Again pose the question; "What is science? " and explain that well-known scientists and activity leaders have been asked this same question. Display the overhead transparency or PowerPoint slides titled "A Few Perspectives on Science," and briefly introduce each in the following order:

   Science is a limitless voyage of joyous exploration. —Walt Whitman

Science is a set of methods designed to describe and interpret observed or inferred phenomena, past or present, and aimed at building a testable body of knowledge open to rejection or confirmation.—Michael Shermer, Director of Skeptics Society

Science is a limited way of knowing, looking at just the natural world and natural causes. There are a lot of ways human beings understand the universe—through literature, theology, aesthetics, art or music.—Dr. Eugenie Scott, Executive Director National, Center for Science Education

We should talk about science not as a noun…but as a process, a set of activities, a way of proceeding and thinking…—Tinker & Thornton. (1992). *Constructing children or youth knowledge in science*, p. 155

2. **Introduce a definition of science.** Display Slide 2: Science is… and emphasize the following generally accepted elements of science:

    - **Evidence-based:** There are accepted methodologies, standards of evidence, and logical ways of answering questions, all of which are based on observations, tests, and other types of data.
    - **Testable or Falsifiable:** How will you know if you are wrong about your idea? If an explanation offers no way to be tested, or does not have the potential to be proven false by evidence, it is not scientific. Repeatability is often a goal in experimental types of science. But much of science does not solve problems through experimentation; they rely on inferences from patterns and observations.
    - **Consistent:** A scientific explanation needs to do more than provide a plausible account; it must fit all the observable facts better than alternative explanations do. It must be consistent with all available evidence, not just selected evidence.
    - **Practical:** An explanation must be useful for solving problems. Science goes by what works, and whatever doesn't work gets thrown out.
    - **Making Explanations:** Scientific explanations must show an explicit cause-and-effect relationship based on observable evidence. This involves looking for patterns and correlations. Explanations deal specifically with the natural world and are not cultural or supernatural.
    - **Reviewed by Peers:** Scientific papers are published in journals to be reviewed by other scientists. Anyone can have an idea in science; it is non-discriminating and it is not sentimental. It doesn't matter who proposes an idea; it is judged based on the evidence. Individual scientists may have lots of different agendas and can put forth a variety of opinions—these don't necessarily represent scientific knowledge. Scientific experts in one field may not know about other fields of science. This is why we look to communities of experts to help ratify explanations and judge the evidence for scientific arguments.
    - **Self-correcting:** Science is open-minded, not empty-headed. Scientists are very careful about what they say they know and how they know it. They try not to overstate their findings and wait to see confirming (or disproving) evidence. This is a strength, in that we are constantly changing and revising scientific ideas.

3. **Introduce what is not science.** Display Slide 3: What Is Not Science… and explain the following points:

Science is not…

- The absolute truth. Rather, it is our current best approximation based on available evidence.
- Democratic. You can't vote on science; it's based on the evidence. It doesn't matter how many scientists there are with a particular opinion. The evidence is what counts. It's also not the authority of the scientist, but the quality of the evidence that provides the strength of the argument.

4. **Explain that science is only one way of knowing.** Ask participants to briefly think about other systems for looking at the world (art, history, philosophy). Emphasize that science is one of many systems for understanding the world around us, but not necessarily a superior system. Point out that science has great predictive value because it is a way of looking at the world with logic and evidence that helps us plan for future events. Many other disciplines also employ logic, and many also employ evidence.

5. **Introduce nature-of-science terms.** Display Slide 4: Terms Used in Describing the Nature of Science. Say that some people may mistakenly think of science as only a pile of facts, but it is much more than that! Unifying principles or themes connect the individual facts, and by intertwining them together using logic and creativity, they form hypotheses, concepts, theories—what some call the "big ideas" of science.

6. **Explain the scientific meaning of each term.** Some people believe that "facts" are absolute truths in science, whereas they are actually our best ideas for now, but inherently disprovable. The word "hypothesis" is often used to mean a prediction, when it actually means a testable statement—one which can again be proved or disproved. "Theory" gets used in everyday contexts to mean a tentative idea when it actually means a well-substantiated explanation. And in science, "laws" are specific to very particular conditions, which are often assumed and not stated. Since these words often have different usage in everyday language, one needs to be very clear about the scientific meaning.

7. **Introduce an activity used to teach about the nature of science.** Tell them that in the next activity they will be taking part in scientific inquiry. They will get an opportunity to do science, both to help them refine their own understanding, and also to model how to teach about the nature and practices of science. It is also an activity that they can use with children and youths.

Inquiry Science Activity (time variable)

NOTE: You will need to present an out-of-school science inquiry activity at this point, which models how the nature of science can be presented to children or youth in an out-of-school setting. This serves as an important application for workshop participants of the concepts addressed in the previous "What is Science" section. It also models how activity leaders can integrate the concepts into their activities with children and youth. Sessions 1 and 2 of the GEMS out-of-school unit, "Oobleck" are well-suited for this purpose. After the activity, go to How We Acted Like Scientists, and Summary of Session to conclude this session.

Concluding the Session (20 minutes)

How We Acted Like Scientists (10 minutes)

1. **Review session activities.** Ask your participants to think back over the entire session, from their first discussions about scientific statements, through their experiences with the inquiry science activity.

   Remind participants of all the activities they took part in. All of these activities involve doing many things that scientists do.

2. **List how they behaved as scientists.** At the top of the chalkboard or whiteboard (or on a piece of chart paper put up where everyone can see), write headings for each step or session of the science inquiry activity you just did. Ask the following:

   Throughout class today, in what ways were you acting as scientists?

   Possible responses related to each part of the session are listed below.

   - Scientific statements: collaborated, discussed, explained, debated, applied knowledge, reflected
   - Science inquiry activity: looked, touched, smelled, wrote ideas, experimented, tested ideas, talked, used instruments (plastic spoons, etc.), compared with things we know about, talked, disagreed, argued, explained our experiments, changed words, defined words, criticized, did more experiments, voted, decided if we thought something was accurate, changed ideas.

3. **Connect responses back to the list of "What is Science?"** As appropriate, connect the scientific behaviors they suggest to the first chart they generated about the characteristics of science. Explain that this is how these activities can be used to teach about the nature and practices of science.

Summary of Session (10 minutes)

1. **Display Slide 5: Summary of Session.** Tell participants that they now have a general picture of the nature and practices of science in its quest for understanding. Emphasize these main points:
   - Scientists use a wide range of investigation methods.
   - Science is based on observations and hypotheses within a testable framework of ideas.
   - Scientific results must be able to be repeatable/replicable in order to be considered valid.
   - Science is a collaborative enterprise.
   - Scientific knowledge evolves over time.

2. **Discuss some of the drawbacks encountered in science.** Point out that this quest sometimes goes astray or "misses the mark." Ask participants to brainstorm potential pitfalls and stumbling blocks of science. Ask:
   - When is science not science because it is not all these things?
   - What makes something a pseudoscience, and not science?

- Are there types of questions science cannot answer?
-

3. **Distribute handouts.** Pass out the following handouts to each participant:
   - Handout 1: Science is…
   - Handout 2: Terms used in Describing the Nature of Science

Scientific Statements

- Every human possesses a soul.
- Water boils at 100 degrees Celsius and 1 atmosphere (atm) pressure.
- Aliens from another planet built the Egyptian pyramids.
- People born under the astrological sign Aries are charismatic leaders.
- All objects are attracted to other objects with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them.
- The Earth's surface is divided into many plates. The movements of these plates set in motion forces that result in earthquakes, volcanoes, and mountain building. The continents are embedded in these plates and are carried around by their movement.
- We hired scientists to test our product, and the results prove our product is better than that of our competition.
- If there is magic on this planet, it is contained in water. (from The Immense Journey, 1957)
- Mugwort is an antidote for poison oak. It can often be found growing near poison oak because nature often provides solutions for plants that may cause people problems.
- The mind is a blank slate at birth. Whatever the child becomes is entirely a function of the experiences to which they are subjected as they grow.

Slide 1

A Few Perspectives on Science

Science is a limited way of knowing, looking at just the natural world and natural causes. There are a lot of ways human beings understand the universe—through literature, theology, aesthetics, art or music.

Dr. Eugenie Scott, Executive Director, National Center for Science Education

Science is a set of methods designed to describe and interpret observed or inferred phenomena, past or present, and aimed at building a testable body of knowledge open to rejection or confirmation.

Michael Shermer, Director of Skeptics Society

Science is a limitless voyage of joyous exploration.

Walt Whitman

Slide 2/Handout 1

Science is …

- Evidence-based
- Testable or Falsifiable
- Consistent
- Practical
- Making Explanations
- Reviewed by Peers
- Self-correcting

Slide 3/handout 1

Science is not…

- **The absolute truth.**
  Rather, it is our current best approximation based on available evidence.

- **Democratic.**
  You can't vote on science; it's based on the evidence. It doesn't matter how many scientists there are with a particular opinion. The evidence is what counts. It's also not the authority of the scientist, but the quality of the evidence that provides the strength of the argument.

Slide 4/Handout 2

Terms Used in Describing the Nature of Science*

Fact: In science, an observation that has been repeatedly confirmed and for all practical purposes is accepted as "true." Truth in science, however, is never final, and what is accepted as a fact today may be modified or even discarded tomorrow.

Hypothesis: A tentative statement about the natural world leading to deductions that can be tested. If the deductions are verified, the hypothesis is provisionally corroborated. If the deductions are found to be incorrect, the original hypothesis is proved false and must be abandoned or modified. Hypotheses can be used to build more complex inferences and explanations.

Law: A descriptive generalization about how some aspect of the natural world behaves under stated circumstances.

Theory: In science, a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses.

Slide 5

Summary of Session

- Scientists use a wide range of investigation methods.
- Science is based on observations and hypotheses within a testable framework of ideas.
- Scientific results must be able to be replicated in order to be valid.
- Science is a collaborative enterprise.
- Scientific knowledge evolves over time.

Questioning Strategies (30 minutes)

Overview

Questions can open doors at every stage of the learning experience, inviting students into activities and ideas by creating interest in a new topic; helping guide explorations; introducing new concepts; and encouraging students to apply their ideas to different situations. Skilled instructors use questions to find out what students think, and draw attention to conflicting ideas. Well-sequenced questions can initiate the sharing of ideas, encourage divergent thinking, help learners recall prior knowledge, allow them to synthesize new information, and help guide logical thinking. Much of quality discussion leading hinges on effective questioning strategies. Discussion leading is an art, and perhaps the most important teaching skill instructors need to learn to be effective.

During this session, activity leaders get a chance to think about and learn how different kinds and sequences of questions affect children or youth. They learn about broad and focused questions, and the appropriate use of each kind. They also learn appropriate sequencing of questions. They explore the effects of an activity leader's perceived role on how they approach questioning with their children or youths. The lesson also addresses issues relating to creating a safe environment for learning and discussion.

Although education researchers have identified many categories and subcategories of questions, we've chosen to focus on two main groups: "broad" and "focused" questions, also referred to in some education literature as "open" and "closed." By this distinction, we in no way intend to classify these question types as either good or bad. This session focuses on the appropriate use of both types of questions. The emphasis is on analyzing the impact of both kinds of questions on children's and youth's thinking and behavior, and using this information to help decide how and when to best use them.

In addition, we focus on the appropriate sequencing of questions, both to lead children and youth through learning cycle-based explorations, and to help guide discussions.

> **NOTE**: This session can be effectively combined with the Role of the Activity Leader session to make an hour-long session on questioning strategies and the role of an activity leader. If you choose to combine these two sessions, we suggest starting with the role of the activity leader skits and discussion, then going into questioning strategies. The discussion led with participants after each skit can be used as an example of the discussion map when this is introduced in the Questioning Strategies session. The skits can also be re-examined with a focus on usage of broad and focused questions.

Session Objectives

In this session, participants:

- experience and reflect on the different effects of focused and broad questions on thinking and discussions of children and youth;
- are introduced to a discussion map to help lead meaningful discussions;
- apply what they've learned about questioning strategies as they prepare their own set of questions to guide activities with children or youth.

Session Activities At a Glance

Introduce Questioning and Describing the Object Activity (15 minutes)
This session starts off with the brief Describing the Object activity in which the instructor asks participants a series of guiding questions. The participants are then asked to notice the different effects that broad and focused questions had on their own thinking and participation in discussion. The effects are quite striking, as discussion emerges naturally when broad questions are used, and tends to end abruptly with focused questions.

Introduce Discussion Map (5 minutes)
The group is then introduced to the idea of using a "map" to lead successful discussions in which they learn to:
- Ask a broad question
- Listen to responses and reasoning
- Ask for evidence or explanation
- Ask for alternative opinions or ideas

Participants Write Own Questions (10 minutes)
Participants apply what they've learned about questioning strategies as they work in small groups to plan a series of questions to ask children or youth in one of the activities participants are planning to lead with them.

What You Need
For the class:
- Slide 1: ?
- Slide 2: Types of Questions
- Slide 3: Discussion Map
- Slide 4: Discussion Map Example (optional).
- Slide 5: Role of the Activity Leader (Only if you have already presented the session Comparing Activity Leader Approaches)
- 1 overhead projector or LCD projector and computer with Powerpoint

For each participant:
Handout 1: Discussion Map

For the Describe the Object Activity:

For the class:
3 different, large, related items (see note)

NOTE: You will hold up these three different items for all to see as they briefly discuss their observations of them in groups of two. The items can be any items you have handy, as long as they are large enough to be visible to the group and interesting to discuss and compare with each other. They should also be topically related to each other, such as a shell, a skull, and a bone (to inspire discussion about the hard parts of organisms), a solid, a liquid, and a gas (to inspire discussion about states of matter), or a rock, a piece of plastic, and a shell (to inspire discussion about natural and unnatural objects).

Getting Ready

1. **Assemble the materials.** Set out the three items you've chosen for the Describe the Object activity.

2. **Make overhead transparencies** (if you are not using PowerPoint) of the following slides:
   - Slide 1: "?"
   - Slide 2: Types of Questions"
   - Slide 3: Discussion Map"
   - Slide 4: Discussion Map Example (optional).

3. **Duplicate handouts.** For each participant, make one copy of Handout 1: Discussion Map.

Introducing Questioning and Describing the Object Activity (15 minutes)

Introduce Questioning

1. **Display Slide 1.** On the overhead projector or using PowerPoint and an LCD projector, project Slide 1 that shows a large question mark to intrigue participants as they enter the room, and as the lesson begins.

2. **Explain the importance of questioning strategies.** Explain that the ability to lead/facilitate successful meaning-building discussions, to inspire higher-level thinking, and to find out how children or youth are developing their understanding are all grounded in the activity leader's ability to ask questions.

3. **Explain that good questioning can enhance a learning experience.** While the topic of "how to ask questions" may seem trivial to some, developing good questioning strategies is what elevates an activity leader to the level of being an "artist of discourse." To put it another way, a lack of good questioning strategies can seriously undermine an activity leader's effectiveness. Even the best activities can lead nowhere if they do not involve the thoughtful use of questions. A skilled questioner can help turn even a brief interaction with children or youth into a deeply meaningful and engaging experience. A lack of good questioning strategies, however, can prevent an interaction from becoming meaningful, or even cause children or youth to become disinterested in a subject.

4. **Point out that carefully planned questions have been used in the workshop.** Point out that in the activities meant for children and youth in the workshop, the presenters were asking carefully thought-out questions meant to inspire higher-level thinking and further investigation.

5. **Explain that statements requiring a response can be categorized as questions.** Tell them that a question can be defined broadly as any utterance that requires a response. Show how a question can be rephrased as a directive statement, and alternatively a directive statement can be rephrased as a question. Refer to the examples given below.

   Question: What do you notice about what the animal is doing?
   Statement: Describe what you notice about what the animal is doing.

6. **Explain that in this session you will be using that broader definition of question—as anything requiring a response.**

Describe the Object Activity

1. **Ask partners to describe the first object.** Hold up the first object. Ask, (1) What do you observe about this object? (2) How might you describe this object to your partner? Tell each group of two to observe and describe what you are holding up to their partners.

2. **Ask partners to describe the second object, and compare it with the first object.** After about one minute, hold up the second object with your other hand. Ask, (1) What do you

observe about this object? (2) How might you describe this object to your partner? Tell them to observe and describe what you are holding in this hand, and compare it with what you are holding with the other hand. Ask, (3) How does this object compare with the other object?

3. **Ask partners to describe the third object, and compare it with the first and second objects.** After another minute, hold up the third object. Ask them to observe and describe it, and compare it with the other two objects using the above questions 1, 2, and 3.

4. **Ask what each object is in succession.** After about one minute, hold up the first object again and ask, (4) What is this object?" Do this with each of the three objects in succession.

5. **Ask other focused questions about the objects.** Ask any other focused questions that seem appropriate, in this case,
   - Which of these is from inside the body of an animal?
   - What kind of animal is this from?
   - Which of these takes the shape of its container?
   - Which is from a mammal?
   - Which of these is from a reptile?
   - Which of these was made by people?
   - Which was made from oil?

Introduce Broad and Focused Questions

1. **Display Slide 2: Types of Questions.**

2. **Introduce broad and focused questions.** Explain that the questions you just used can be put into the two general categories of broad and focused questions.

3. **Emphasize that each type of question generates a different kind of response.** Point out that neither type of question should be considered "good" or "bad," but that they each generate different types of responses. For this reason, activity leaders need to be aware of the particular circumstances in which it is best to use different types of questions.

4. **Identify questions 1-3 as broad questions.** Tell them that questions1-3 fall into the category of broad questions:

Questions 1–3:
1. What do you observe about this object?
2. How might you describe this object to your partner?
3. How does this object compare with the other objects?

5. **Discuss how broad questions influence discussion.** Ask them to reflect on how these broad questions influenced the interactions in their discussions. Allow ample wait time for participants to begin sharing their observations. Their ideas may include the following:
   - Encouraged us to interact with the materials
   - Opened up discussion
   - Had more than one acceptable answer

- Encouraged divergent thinking

6. **Identify question 4 and the additional questions as focused questions.** Tell them that these questions fall into the category of focused questions:

4. What is this object?
- Which of these is from a gastropod?
- Which of these is from inside the body of an animal?
- What kind of animal is this from?
- Which is from a mammal?
- Which of these is from a reptile?
- Which of these was made by people?
- Which was made from oil?

7. **Discuss how focused questions influence discussion.** Ask about the effect of these focused questions on the small-group discussions. Again, allow for a few participants to share their reflections. Among other responses, they may say:
   - Required us to recall specific information
   - Focused our response on the topic of types of organisms.
   - Kept the interchange short and to the point

Using Broad and Focused Questions

1. **Display Slide 2: Types of Questions again.**

2. **Explain disadvantages of using focused questions for discussions.** Suggest to participants that, in general, focused questions are not good for starting discussions. A common mistake made by activity leaders is to begin a discussion by asking a focused question and when learners do not readily respond, trying to reword the same question and give hints about the specific response they expect.

3. **Point out that most activity leaders underutilize broad questions.** Explain that through observations of classroom teachers, it has been found that focused questions make up a full 80% of the questions asked of students. Again, point out that focused questions are not inherently bad, but it seems that most activity leaders underutilize broad questions in educational settings.

4. **Pose a series of scripted questions.** To illustrate this point, ask the following questions, in rapid-fire fashion, one right after the other:

   - Do you think I could start a discussion by asking this narrow question? [no]
   - What kind of question would be better for starting a discussion? [the answer to this narrow question is "broad"]
   - Am I using broad questions right now? [no]
   - A discussion isn't starting is it? [no]
   - What are some situations or goals for which narrow questions might be appropriate? (Make sure to give time for a few participants to respond.)

5. **Point out different effects of focused and broad questions.** Point out that the first four questions you just asked were obviously all focused questions, and the last was a broad question. Once again, ask them to notice the different effects that the questions had on the class discussion.

6. **Emphasize that broad questions lead to divergent answers, and focused to specific.** Summarize the discussion by emphasizing to participants that broad questions lead to divergent answers, and focused questions lead to specific answers. Introduce the idea that, just as focused questions are generally inappropriate for initiating discussion, activity leaders should not ask a broad question if they are looking for a specific answer or want to wrap-up a discussion.

7. **Relate questioning strategies to previous course sessions.** Point out that the questions used during discussions in previous activities of the course were thoughtfully planned and used with this kind of interplay between broad and focused questions in mind.

NOTE: If you have already done the Role of the Activity Leader activity with your participants, you may want to re-examine the skits focusing on the use of broad and focused questions.

Introduce the Discussion Map (5 minutes)

1. **Introduce discussion maps.** Researchers have studied effective strategies for leading discussions, and have developed the idea of a "discussion map" to reflect how skilled discussion leaders tend to guide and encourage discussion. This map can be applied to discussions with any age group.

2. **Display the discussion map.** Project Slide 3: Discussion Map, and read each step aloud:
   - Ask a broad question
   - Listen to responses and reasoning
   - Ask for evidence or explanations
   - Ask for alternative opinions or ideas
   - Ask a question leading back to the main topic

3. *Optional*: **Indicate how the questions fit the discussion map.** If you have already done the Comparing Activity Leader Approaches activity with your participants, relate the discussion map to the skit discussions. Show Slide 4: Discussion Map Example. Review the questions shown on the slide, and how they fit in with the discussion map.

Ask a broad question:
- **How would you describe the interaction between the activity leader and the children in the first skit?**

Listen to response and thinking.

Ask for evidence or explanation:
- **What about what the activity leader said or did makes you think that?**

Ask for alternative opinions or ideas:

- **Does anybody have a different idea or opinion?**

Ask a question leading back to the main topic
- **How do you think the activity leader saw his or her role as an activity leader?**

4. **Describe the usefulness of the discussion map.** Suggest that this discussion map model is well-suited for an activity leader who seeks to facilitate children's and youth's constructing their own conceptual understanding. The discussion map idea is very useful, but it is not intended to be a full description of discussion strategies. It works best when it is seen as a flexible model rather than a lockstep procedure.

Planning Questions

1. **Explain that it is good to plan questions.** Explain that when working with any children or youth, it is important to be able to think on your feet and improvise questions and responses, but it's always a good idea to have an overall plan for questioning.

2. **Have groups plan questions.** Tell participants they'll be working in small groups. Each group will choose an activity they plan to lead with children or youth, and generate questions they might use to encourage exploration and lead discussions. The goal is to focus on questions that facilitate taking a student even further in their investigations and understanding. They should also remember to include some broad questions to encourage divergent thinking.

3. **Explain why this exercise is helpful.** Add that this exercise is helpful for several reasons:
   - Most activity leaders ask broad and focused questions randomly, or use only one type at a time.
   - Children or youth can derive more meaning from an activity when questions are thoughtfully planned to address specific learning objectives.
   - Without a plan, activity leaders often fall back on teaching in the manner in which they were taught.

Slide 1

?

Broad

Focused

Slide 3

Discussion Map

- Ask a broad question
- Listen to student response(s) and try find out their ideas
- Ask for the evidence for their explanation
- Ask for alternative opinions or ideas
- Ask a question leading back to the main discussion topic

Slide 4

Discussion Map Example

- How would you describe the interaction between the activity leader and the children in the first skit?

- What about what the activity leader said or did makes you think that?

- Does anybody have a different idea or opinion?

- How do you think the activity leader saw his or her role as an activity leader?

Handout 1

Discussion Map

An activity leader encouraging students to construct their own conceptual understanding can use a structure for questioning that encourages discussion and helps to "unpack" misconceptions.

- Ask a broad question
- Listen to student response(s) and try find out their ideas
- Ask for the evidence for their explanation
- Ask for alternative opinions or ideas
- Ask a question leading back to the main discussion topic

Role of the Activity Leader (30 minutes)

Overview

The way activity leaders see their role can strongly influence the tone of an activity and what children or youth get out of it. The best role for an activity leader to take on when leading the activities recommended in this manual is that of a *"guide on the side."* In this role, the activity leader is a facilitator of doing and learning, and the focus is not on the leader, but on the children or youth. The activity leader asks questions that engage children or youth and stimulate their thinking, provides clear instructions and guidelines, and coaches the children or youth through the activities, when it seems helpful. The activity leader helps children or youth make sense of their discoveries, and helps them discuss their ideas with others in the group.

This session includes three skits to be acted out by participants. Each skit is the same setting, but the activity leader in each skit represents a different perceived role. The first skit represents an activity leader who acts as a *"sage on the stage,"* which is essentially the opposite of a *guide on the side*. This activity leader is the focus of attention and attempts to give knowledge to the children or youth, which is counter to research on effective educational activity leading. The second skit represents a *guide on the side* approach, and participants discuss the contrasts and effectiveness in the two approaches. This skit helps show how a thoughtful facilitator can encourage thinking and investigating in children or youth. The third skit includes an activity leader who acts as an *entertainer*—still a *sage on the stage*—but engaging. This is a very common perceived role of activity leaders. The discussion after the third skit provides an opportunity for activity leaders to think about and discuss the merits and disadvantages of this approach, and to re-evaluate how their own perceived roles as activity leaders may affect children or youth and learning in their sessions.

> **NOTE**: This session can be effectively combined with the Questioning Strategies session to make an hour long session on questioning strategies and the role of an activity leader. If you choose to combine these two sessions, we suggest starting with the role of the activity leader skits and discussion, then going into questioning strategies. The discussion led with participants after each skit can be used as an example of the discussion map when this is introduced in the Questioning Strategies session. The skits can also be re-examined with a focus on usage of broad and focused questions.

Session Objectives

In this session, participants note the impact on children or youth when an activity leader sees his or her role as either *guide on the side*, *sage on the stage*, or *entertainer*.

Session Activities At a Glance

Role of the Activity Leader, Skits #1 & #2 & Debrief (15 minutes)

Two brief skits are acted out, depicting the interactions between an activity leader and two children. The first illustrates the *sage on the stage* approach to teaching, while the second portrays the *guide on the side* approach. During follow-up discussions, participants discuss the pros and cons of each approach.

Discuss the Role of the Activity Leader (5 minutes)

The presenter introduces the terms *guide on the side* and *sage on the stage*, and how an activity leader's approach and assumptions about learning influence activities with children or youth.

Role of the Activity Leader, Skit #3 & Debrief (10 minutes)

A third skit is acted out, illustrating the *entertainer* approach. During follow-up discussions, participants discuss pros and cons of this approach, and how it can be more effective when combined with the *guide on the side*.

What You Need

For the whole class:

- 4 copies of the three skit scripts—one for yourself and one for each of the three skit participants
- 1 tub of water (about the size of a dish tub), preferably clear
- all the following items need to be large enough for the group to see, but small enough to be able to fit in the tub:
  - 2 rocks, one large and one small
  - 1 piece of Styrofoam
  - 1 metal spoon
  - 1 binder clip
  - 1 piece of wood
  - 1 paper clip
  - 1 large piece of wax
  - 1 medium piece of wax
  - 1 small piece of wax
  - 1 grain of sand (keep some extras on hand in case you lose it)

Getting Ready

Make four copies of the skit scripts, one for yourself and three for the skit participants.

Role of the Activity Leader, Skits #1 & #2 & Debrief

1. **Introduce the idea of the role of the activity leader.** Tell the participants that in addition to being aware of different types of questions and their uses, how activity leaders see their role with children or youth also influences their questioning style.

2. **Introduce the two skits.** Let participants know that they will watch (or participate it) two separate skits involving the interactions between an activity leader and two children (Anita and Jenner). Each skit illustrates a different approach to the activity leader's role, as well as appropriate and inappropriate uses of both broad and focused questions.

3. **Ask for three volunteers to come forward and read the parts of an activity leader and two children (Jenner and Anita).** Show them the materials you have set out for them. Instruct them to speak loudly. Tell them to read and act out the script for skit #1.

Discuss Out-of-School Activity Leader Skit #1

1. **Discuss the first skit using scripted questions.** After the skit, lead a discussion with the participants asking the following questions (where/when appropriate) in order to debrief the skit:

    - How would you describe the interaction between the activity leader and the children in the first skit?
    - What did the activity leader say or do to make you think that?
    - Does anybody have a different idea or opinion?
    - How do you think the activity leader saw his or her role as an activity leader?

2. **Focus on the behavior of the activity leader.** If participants don't mention the following points about what the activity leader did in skit #1, mention some yourself:

    - Did not effectively find out what the children were thinking by using probing questions.
    - Had an intimidating and condescending attitude, which made children reluctant to participate.
    - Talked a lot, probably partly because the children did not feel comfortable talking much.
    - When children brought up things the leader didn't know about, like the floating rock, he or she brushed it aside and changed the subject.
    - Commanded the children to think, even as he or she was discouraging real thinking through the questions being asked.
    - Used a barrage of focused questions which, when answered, may give the impression of comprehension, but could easily have been parroted without any real understanding on the child's part.
    - Introduced content (density) too early when the children weren't ready for it.
    - Put children on the spot when asking them questions.

Enact and Discuss Out-of-School Activity Leader Skit #2

1. **Have volunteers enact skit #2.** Tell participants they will now see how the same situation might play out with a different approach. Either use the same volunteers or ask for three new volunteers and assign them to the same roles of activity leader and two children. Give them their scripts for Activity Leader Skit #2, and keep one for yourself. Remind the volunteers to read their parts loudly.

2. **Use the same specific questions to discuss the second skit.** After the skit, ask participants to describe the interaction between the activity leader and children in the second skit, and how they think the activity leader saw his or her role as an activity leader. Use the following series of questions:

    - How would you describe the interaction between the activity leader and the children in the second skit?
    - What did the activity leader say or do to make you think that?
    - Does anybody have a different idea or opinion?
    - How do you think the activity leader saw his or her role as an activity leader?

3. **Focus on the behavior of the activity leader.** If participants do not bring up the following points about what the activity leader did in skit #2, mention some yourself:

   - Made an effort to validate the children's points of view so as not to intimidate them.
   - Acted as a collaborator in investigating the answer.
   - Asked questions to find out what the children were thinking.
   - Did not talk too much. Instead, facilitated students' talking.
   - Did not give pat answers, but instead provided a guided opportunity for the children to figure them out for themselves.
   - Did not tell the children if they were right or wrong, but helped them look at the evidence to find out for themselves.
   - Replied to the children's response to broad questions with accepting responses, encouraging the children to go further.
   - Did not try to cram in everything they knew about sinking, floating, and density. Helped guide the children towards some ideas that came out of their explorations.
   - After one child voiced an idea, the activity leader asked what the other child thought.
   - When the children brought up things the leader didn't know about, like the floating rock, he or she respected their contribution and tied it into the exploration.

Discuss the Role of an Activity Leader

1. **Introduce *guide on the side* and *sage on the stage*.** Explain that an activity leader's attitude about asking questions is often reflected according to the role that person adopts as an activity leader. Share two well-known expressions used as shorthand to describe two possible roles—an activity leader can act either as a *guide on the side* or as a *sage on the stage*.

2. **Point out how the sage on the stage sees him- or herself as transmitter of knowledge.** The first skit represents the *sage on the stage* activity leader role. In this approach, the activity leader is the transmitter of knowledge. The activity leader sends out the information; the learner receives it. There is a sense of the activity leader as the recognized authority and the repository of information on whatever subject is being taught. This attitude can be described as, "I know about this and you don't, so I'm going to tell you the right answer." It reflects the idea of education as transmission of information from one source to another.

3. **Point out how *guide on the side* sees him- or herself as facilitator of learning.** The second skit represents the *guide on the side* type of activity leader role. The attitude in this approach is one of shared inquiry, collaborators in an investigation, trying to figure something out together. This role sees the activity leader as a facilitator of learning. This mode of teaching reflects an approach that focuses on the thinking, or cognition, of the learner—the activity leader allows children or youth to express their ideas, illuminates any conflicts, and then guides them to reinforce, alter, or replace their ideas.

Enact and Discuss Out-of-School Activity Leader Skit #3

1. **Volunteers enact skit #3.** Tell participants they will now watch or participate in one more teaching approach to the same situation. Assign volunteers to the three roles, pass out the scripts, and begin.

2. **Discuss the third skit.** Ask participants to describe the interaction between the activity leader and children in the third skit, and how they think the activity leader saw his or her role as an educator.

3. **Focus on the behavior of the activity leader.** If participants do not bring up the following points about what the activity leader did in skit #3, then mention some yourself:
   - Engaged the children.
   - Saw his or her role as a performer.
   - Saw his or her job as dispensing knowledge to the children in a fun manner.
   - Never found out what the children's ideas were.
   - Did not provide the children with any opportunity to struggle with ideas or engage in higher-level thinking.
   - Did not seem to value giving the children an opportunity to do science, but seemed content to let them enjoy watching him or her talk about science facts and do quick demos.
   - The children thought the activity leader was cool, but did not get a chance to feel that they could use science to investigate a topic themselves.
   - The children enjoyed acting out molecules, but probably didn't understand what they were doing, and would have difficulty connecting the information to the substances that sink or float.
   - The acting out of molecules probably distracted students from thinking about the substances, even though the model was meant to help them understand them better.
   - Drilled them in a word they probably didn't understand, so even if they remember the word in the future, they will probably misuse it.
   - The "check for understanding"—"hey, what were those games about?"—did not really check for understanding; it only served to find out if the children could remember and say the word.
   - Entertained and excited the children with the presentation, but the children probably learned very little.

4. **Introduce the *entertainer*.** Point out that this kind of teaching—the charismatic and entertaining activity leader conveying information in a fun manner—is considered by many members of our culture to be ideal teaching. Yet, although it may be engaging, it goes against many of the things we know about how people learn: that learners must build upon prior knowledge, construct their own conceptual frameworks, and reflect upon their own learning. Passively receiving information—even while having a good time—does not guarantee that learners are making sense of or retaining what is being presented.

5. **Point out reasons that entertaining activity leaders may get recognition.** One of the problems with trying to get people who lead educational activities in this manner to consider other ways is that this type of activity leading often gets reinforced by other adults who haven't thought about the long-term drawbacks. A less showy activity leader who acts more as a

facilitator of learning may get positive responses too, but may also get less recognition. Occasionally, some children or their parents who are accustomed to simply receiving information from a teacher or activity leader may even complain if an activity leader encourages discussion and thinking without giving out a lot of answers.

6. **Explain that activity leader #3 had good skills that could be better used.** The activity leader in skit #3 had engagement skills and a positive encouraging attitude that could make him or her an excellent teacher, if he or she used those skills while also leading the activity more as a *guide on the side.*

> **NOTE**: The above distinction is useful to get a very important point across, but in a larger discussion, needs to be qualified and placed into non-stereotypical context. It is also not intended to imply that these two approaches are mutually exclusive. Teaching takes place along a continuum that combines many approaches. Even the most seemingly straightforward classroom situation is made up of many complex children- or youth-activity leader interactions. As with questions, there is a time and a place for many different approaches.

Out-of-School Activity Leader Skit #1

The scene is an out-of-school activity about which objects sink and float in water. An activity leader is leading a discussion about the children's discoveries after they have explored with the materials.

Activity Leader: I saw you doing a lot of sinking and floating investigations. What did you learn?
Blank look from children
Activity Leader: C'mon I know you learned something. Can someone say something they learned?
Jenner: I learned that if you put a rock on a piece of Styrofoam it floats.
Activity Leader: No, not about putting things on top of each other. What did you learn about things that float and sink by themselves?
Children are quiet. After a while Anita raises her hand.
Anita: By itself, the rock sank
Activity Leader: Yeah, but what kind of general statement can you say about things that sink and float?
Children look confused
The rock was heavy, right? And the rock sank. So what can you say about what kinds of things sink and what kinds of things float?
Children are quiet. After a while Anita raises her hand.
Anita: Heavy things sink, and light things float?
Activity Leader: But what about ships? They're heavy and they float.
Children look confused.
Activity Leader: Who can make a better statement about the kinds of things that floated and sank?
Children look confused.
Activity Leader: OK then, look at this piece of Styrofoam. Did it float or sink?
Jenner: It floated.
Activity Leader: Why?
Jenner: I don't know. *Pause* Because it's light?
Activity Leader: No, remember that ships aren't light, but they float, so that's not the reason.
Children look confused.
Activity Leader: Well actually it's things with more density than water that sink, and things with less density than water that float. So for example, this piece of Styrofoam is less dense than water, and watch.
Sets Styrofoam in water
See, it floats. But this spoon is more dense than water and watch what happens when I put it in water.
Sets metal spoon in water It sinks.
See this binder clip? Anita, do you think it's more dense or less dense than water?
Anita: I dunno.
Activity Leader: C'mon, think! Is it more dense or less dense than water?
Anita: *tentatively* Less?
Activity Leader: No. It's more dense. Let me show you.
Sets binder clip in water
See it sinks. That's because it's more dense than water.
Holds up piece of wood
What about this piece of wood. Do you think it's more dense or less dense than water?
Children look confused and intimidated.

Activity Leader: Jenner, what do you think?
Jenner: nervously I dunno.
Activity Leader: Is it more dense or less dense than water?
Jenner: Less dense?
Activity Leader: That's right, it's less dense than water. So when we put it in water what'll it do?
Jenner: I'm not sure.
Activity Leader: Will it sink or will it…*waits for Jenner to finish the sentence*
Jenner: Float?
Activity Leader: Right! It'll float. So our prediction is that it will float. Let's try it out. Sets piece of wood in the water
Yep, we were right, it floated.
Holding up paper clip.
What about this paper clip? Let's test if it's more or less dense than water. What do you predict?
Anita and Jenner both speak at the same time
Anita: Less
Jenner: More
Activity Leader: Let's test it.
Sets paper clip in the water.
See? Jenner was right. It's more dense than water. It sank.
Anita: But when I put it in the water real slowly it floated.
Activity Leader: Well, I don't know what you think you saw, but metal paper clips are more dense than water, so they sink.
Jenner: I heard there's a kind of rock that floats.
Activity Leader: I find that hard to believe, because rocks are more dense than water. Rocks sink.
Activity Leader: So everyone say density.
Jenner and Anita: Density.
Activity Leader: What did we learn about today?
Jenner and Anita: Density.

Out-of-School Activity Leader Skit #2

Activity Leader: I saw you doing a lot of sinking and floating investigations. I'd like to hear about some of your discoveries. I saw some people come up with clever tricks to make floaters sink and sinkers float. But can anyone make a statement about what kinds of things float or sink without "tricks?"
Anita: Heavy things sink, and light things float.
Activity Leader: Can you show us something heavy that you tested.
Anita: A rock.
Picks up rock.
Activity Leader: Someone else feel it.
Passes rock to Jenner.
Does it feel heavy?
Jenner: Yeah it feels heavy.
Activity Leader: Let's test if it floats or sinks.
Sets rock in water.
Hmm looks like it does sink. Did anyone else test something heavy that sank?
Jenner: *Picks up spoon.* Yeah, I tested a spoon.
Activity Leader: Does that spoon feel heavy to you?
Anita: Kind of. It feels heavier than a plastic spoon.
Activity Leader: OK, now let's test it.
Sets spoon in water.
Jenner: It sank.
Activity Leader: We tested two things you thought were heavy and they both sank. Let's test something that feels light now. Can someone show us a light object that floated when they tested it?
Anita picks up small piece of wax.
This piece of wax is light and it floated.
Activity Leader: Do you all agree that it's light? Let's try it out.
Sets wax in water.
Yeah, it does float, doesn't it? We tested something that was light and floated, so the evidence seems to support the statement. OK, now to test this statement some more, let's see if we can think of any heavy things that float or light things that sink.
Jenner: A ship floats.
Anita: That's cause it's hollow.
Jenner: But a big huge log can float, and they're not hollow.
Activity Leader: Hmm. Ships are heavy and they do float, and so do big logs. So It looks like we're going to have to change our statement to match that evidence. But before we do that, let's do some more testing of objects we have here. I've got another rock, but it's smaller than the other one.
Hold up grain of sand
Go ahead and feel the weight.
Passes grain of sand to each child to feel weight
What do you say heavy or light?
Jenner: Light.
Anita: Very light. I can hardly even feel any weight.
Activity Leader: Do you think this tiny light weight rock will sink or float?
Jenner: Float.

Anita: I think it might sink.
Activity Leader: Well let's test the idea that light objects float. Let's test to see if this light object floats.
Sets grain of sand in water
Anita: It sank!
Activity Leader: So I guess we can't say that all light things float, can we?
Jenner: We can say some light things float.
Activity Leader: Let's test out the "heavy things sink" statement too now. Here's another piece of wax. Go ahead and feel its weight compared to the rock.
Passes large chunk of wax to each child to feel
Does it feel heavy or light?
Anita: It's heavier than the rock.
Activity Leader: Do you predict that it will sink or float?
Anita: It'll sink.
Jenner: Maybe it'll float.
Activity Leader: Let's try it, and see if this heavy thing sinks or floats.
Sets large piece of wax in water
Jenner: It floated!
Activity Leader: So we found something that feels heavy, but it didn't sink. It floated. Let's try another piece of wax, to see if it floats.
Holds up medium sized wax
This one is sort of medium in size and weight. Do you predict that it will float or sink?
Jenner: I think it'll float.
Anita: Yeah, it'll float.
Activity Leader: Let's test it.
Sets medium sized wax in water
It floated.
Jenner: I was right!
Anita: So was I!
Activity Leader: So it looks like we're going to have to change our statement about heavy things sinking and light things floating. Any ideas?
Anita: How about a lot of heavy things sink and a lot of light things float?
Activity Leader: What do you think?
Jenner: OK
Activity Leader: Can you think of any other statements we could make? Maybe a statement about wax or rocks?
Jenner: Wax floats and rocks sink.
Activity Leader: Do you think wax of any size floats and any size of rock sinks?
Jenner: Maybe.
Activity Leader: What do you think about that statement Anita? Do you agree?
Anita: Yeah
Activity Leader: Maybe we could find more rocks and wax to test.
Jenner: Yeah.
Anita: I think I heard of a rock that floats.
Activity Leader: Hmm. Well, part of thinking like a scientist is being ready to change our ideas if the evidence doesn't match them, and come up with new ideas. So if we find a rock that floats, we'll have to change our ideas, huh?

Out-of-School Activity Leader Skit #3

Activity Leader: Did you guys have fun doing your sinking and floating investigations?

Jenner and Anita: Yeah! *Enthusiastically and in unison*
Activity Leader: What did you discover?
Jenner: I put a rock on a piece of Styrofoam and made it float.
Activity Leader: Cool! What other things did you discover?
Anita: When I put a paper clip on the water real carefully, it floated. But when I just dropped it in the water, it sank.
Activity Leader: That's really interesting Anita! Good job!
So what I want to talk to you about now is something called density. Everybody say density.
Jenner and Anita: Density!
Activity Leader: You may have heard of people saying that someone is dense if they're not smart. Well it's not that kind of dense. This kind of density has to do with how closely packed the molecules are in an object. When things are more dense, the molecules are more tightly packed together. When things are less dense, the molecules are less tightly packed together. If something has more density than water, it sinks. If it has less density than water, it floats. So check out the rock and the binder clip
Sets the rock and binder clip in the water
Activity Leader: Check it out! They both sink because they have more…
Jenner: Destiny.
Activity Leader: Well maybe they have destiny too, but they sink because they have more density. Everybody say density again.
Jenner and Anita: Density!
Activity Leader: All the other things that sank have more density than water. Now let's check out the Styrofoam and plastic.
Sets the Styrofoam and plastic in the water
Activity Leader: They both float. That's because they both have less density than water. Things with less density than water float.
Who can name something that floats?
Anita: The wood.
Activity Leader: Right, the wood floated, so it has less density than water.
Who can name something that sinks?
Jenner: The rock.
Activity Leader: Right, the rock sank, so it has more density than water.
Can someone name something else that has less density than water?
Jenner: The metal spoon?
Activity Leader: Good guess, but the metal spoon sank so it has more density than water.
Here, let's do a little game to show how density works.
Imagine that the three of us are all molecules in something. See how we're kind of spread out right now? That's like molecules in something with less density. But now let's move in more tightly together.
The activity leader, Jenner and Anita scrunch in more closely
Activity Leader: Now we're like molecules in something that's more dense than water. So this is kind of like the molecules in a rock – tightly packed together. Now let's spread back out a little.

The activity leader, Jenner and Anita move apart a bit
Activity Leader: Now we're like the molecules in something that is less dense than water, like a piece of wood. So show me what molecules look like in something more dense.
Jenner and Anita scrunch in more closely
Activity Leader: Less dense
Jenner and Anita move apart a bit
Activity Leader: More dense
Jenner and Anita scrunch in more closely
Activity Leader: Now show me the density of water.
Jenner moves in and Anita moves out. The activity leader laughs, good-naturedly.
Activity Leader: Pretty good! That was a tricky one, because the density of water is in between the density of wood and a rock.
Activity Leader: What did we learn about today?
Jenner and Anita: Density.
Activity Leader: A little louder!
Jenner and Anita: Density!
Activity Leader: What makes rocks sink?
Cups hand to ear
Jenner and Anita: Density!
Activity Leader: What makes wood float?
Cups hand to ear
Jenner and Anita: Density!
Activity Leader: What makes me mess up on a test?
Cups hand to ear
Jenner and Anita: Density!
Activity Leader: Nah, I'm just playin' with you. Remember that's not the kind of density we're talking about here. Does anybody have any questions?
Jenner: You're fun.
Activity Leader: Thanks so are you.
Anita: I liked it when we did the games.
Activity Leader: Thanks. Hey, what were those games about?
Jenner: Density?
Activity Leader: That's right! You guys learned a lot today!

Comparing Educational Activity Approaches

Overview

There is much research that has been done on how people learn. An awareness of this information is extremely useful to anyone involved in designing or presenting educational activities. This session is designed to open the door on the topic of how people learn best, and how to craft activities that reflect that understanding. Activity leaders go through a varied series of learning stations, each using a different approach to present the same topic. As they visit each station, the participants are challenged to become aware of their own reactions to the different approaches. This shared experience allows for a dynamic discussion of the variety of educational activity approaches there are and the individual learning styles we each have. The presenter introduces how research has been applied to create an instructional model (known as the "learning cycle") focusing on the ordering of different instructional approaches and how that has been a useful tool in planning learning activities.

Traditional classroom and out-of-school science teaching has been oriented towards an instruct-verify-practice approach. In general, whether the source of information be a game that gives information, an activity leader telling information to a group of children, or a science book, the conveyance of information is linear, transmitted from a source to the children or youth. The learning cycle breaks free from this approach to create a model of instruction that is learner-centered in that it addresses needs of the learner. Such instruction takes into account the learner's prior understandings, and need for firsthand experiences, while provoking questions, and enabling the learner to conceptually integrate and apply new concepts and information. The activities for children and youth suggested in Part 2 of this manual have been designed with the learning cycle in mind. Familiarity with the learning cycle helps activity leaders begin to understand why they should follow these carefully designed activity plans, and helps them make educated instructional decisions while leading activities.

The idea of "the learning cycle" has been developed over time by researchers and educators, and refined and deepened in recent years by newer findings in neuroscience and cognitive psychology. The concept refers to a visualization of the learning process in different phases.

Side Bar: The learning cycle model presented in this session is based on a 4-phase cycle including: invitation, exploration, concept invention, and application. There are other models with similar phases but minor variations; some have three main stages, others four or more, but most share a common vision of how learning takes place.

It is important for you as the presenter to be mindful of the fact that this learning cycle concept is in fact a **model**—meant to represent, organize, and categorize main phases in science learning—but not to suggest that this is the only way to conceptualize learning! Nor should it be seen as a rigid or mechanical model—people and their learning processes are gloriously complex, and depending on the person and the content being learned there is no automatic order or sequence in which these phases must take place (although your participants may find, for example, that there are great benefits when one phase precedes or follows another).

Nonetheless, while it's wise to beware of oversimplification, it is also important to emphasize that, based on years of research and application, the learning cycle model can be a powerful and enormously helpful model to use in stimulating thinking about how people learn and in designing and presenting activities that succeed in conveying concepts to children or youth in meaningful and effective ways.

Session Objectives

In this session, participants:

- deepen their understanding of the advantages and limitations of different educational activity approaches;
- understand that different learners have preferences for different educational activity approaches;
- see the importance of providing a group of learners with a balance of different educational activity approaches;
- learn about an effective model for instruction known as "the learning cycle" and gain the ability to analyze how an activity can be constructed to incorporate the learning cycle; and
- become aware of the general power of sequencing different educational activity approaches to achieve greater learning.

Session Activities at a Glance

Total Time: 1 hour and 15 minutes (not including the model learning cycle activity of your choice)

Introduce Workshop and Activity Stations (5 minutes)

This session begins with participants thinking back on how different educational activity approaches have affected them as learners as a way to invite participants to begin thinking about the topic, and accessing any prior information they may have about teaching and learning.

The participants are then briefly introduced to the logistics of rotating through and participating in three activity stations: Open-ended Exploration, Structured Investigation, and Problem-Solving Challenge.

Activity Stations (40 minutes)

Minutes into the session, the groups are engaged in the activities, while simultaneously thinking about how each educational activity approach affects them individually. The participants take part in a modified version of the Ice Cubes activity from the GEMS unit entitled, *Ocean Currents*. They rotate through three Activity Stations: Open-ended Exploration, Structured Investigation, and Problem-Solving Challenge. Then the instructor leads the whole group modeling an "explaining" approach.

Debrief Stations (20 minutes)

After all participants have experienced the four approaches, the presenter leads a probing discussion of their experiences and thoughts, helping the group to compare and contrast the strengths of each kind of educational activity approach. The presenter draws out the fact that different learners have different abilities and preferences for educational activity approaches, highlighting the importance of an activity leader using a variety of approaches.

Introduce Learning Cycle (10 minutes)

The presenter then introduces the instructional model known as the learning cycle, in the following sequence, as a helpful way to think about how people learn:

- invitation
- exploration
- concept invention
- application

The presenter leads participants to understand the logic of sequencing different educational activity approaches.

Model Learning Cycle Activity of Your Choice (variable)

The presenter concludes the session by presenting an activity that exemplifies the Learning Cycle. This is an important step in which the participants apply the theory presented in this activity to an activity they will be presenting with children or youth. Participants are invited to point out the different phases of the cycle and reflect on the power of this order in this particular situation. If you do not have time to present an activity at this point, then be sure to give participants an opportunity to apply the learning cycle to an activity they have already been exposed to, or do so the next time you present a new activity to the group.

Choosing the Model Learning Cycle Activity

Choose which activity for children or youth you want to model at the end of the session. It should be an activity in which the learning cycle steps can be identified fairly easily. Ideally, the activity you present would be one you are very familiar with that is appropriate for the level of your participants and/or their children or youths, as well as being specific in content to your workshop's needs.

What You Need for the Whole Session

For the whole group:

- Slide 1: *The Learning Cycle*
- 1 copy of the Station D "Explaining" sheet
- Overhead Projector or LCD Projector and Computer with Powerpoint

For the Ice Cube Investigation Activity Stations

> **NOTE**: We recommend that for up to 30 participants, one of each of the four stations is adequate. With more than 30, you will want to provide two set-ups of each station, so participants can rotate through them in the time allowed and have a real opportunity to experience each station. Should the number of participants grow even larger, you will need to increase stations and materials accordingly. The materials listed here are for approximately 30 participants with one set-up of each of the four stations with up to 7 participants per station.

For all stations:

- 8 cafeteria trays (or cookie sheets) to carry station materials

For each participant:
- 1 copy of "Structured Activity" sheet for Station B
- 1 copy of "The Learning Cycle" take home sheet

For Station A, Open-Ended Exploration (materials needed to set up one station):
- 2 identical approx. 12 ounce clear containers (plastic cups or beakers)*
- 1 large sheet of paper (a piece of flip chart paper works well)
- food coloring (any dark color – red, blue, dark green, but not yellow)
- small plastic bag or bowl to contain ice cubes
- 1 sponge
- small tub to dispose of used water
- 1 copy of the Station A sign

For Station B, Structured Activity (materials needed to set up one station):
- 2 identical approx. 12 ounce clear containers (plastic cups or beakers); one labeled "salt water", the other labeled "fresh water."*
- 1 large sheet of paper (a piece of flip chart paper works well)
- food coloring (any dark color – red, blue, dark green, but not yellow)
- small plastic bag or bowl to contain ice cubes
- 1 sponge
- small tub to dispose of used water
- 1 copy for each participant of the Station B instructions
- 1 copy of the Station B sign

For Station C, challenge (materials needed to set up one station):
- 2 identical approx. 12 ounce clear containers (plastic cups or beakers)*
- 1 large sheet of paper (a piece of flip chart paper works well)
- food coloring (any dark color – red, blue, dark green, but not yellow)
- small plastic bag or bowl to contain ice cubes
- 1 sponge
- small tub to dispose of used water
- 1 copy of the Station C sign

NOTE: These bottles will need to be refilled at the start of each station rotation

For Station D, explaining:
- 1 copy of the Station D Explaining sheet for yourself.

For the entire group:
- ice cubes
- 1 pitcher of tap water, unlabeled
- 1 pitcher of salt water, unlabeled
- paper towels
- kosher salt
- stir stick or spoon

Getting Ready

Before the Day You Present the Session:

For the Ice Cube Investigation Activity Stations:

1. **Copy station signs.** Make enough signs to have one for each station you are setting up. You might want to laminate the station signs because they are likely to get wet. (pages XX-XX)

2. **Copy "Explaining" sheet.** Make one copy of the Station D Explaining sheet for yourself. Read the sheet carefully, so you understand the explanation, and can deliver the information to the group. The information on the sheet could be simply read aloud, but it is better to deliver the explanation more in your own words without reading it.

3. **Copy The Learning Cycle transparency.** Make one copy of the overhead transparency or power point slide *The Learning Cycle* (page XX)

4. **Make copies for each participant and set aside:**
   - 1 copy of "Structured Activity" sheet (two sided master, pages XX)
   - 1 copy of "The Learning Cycle" sheet (page XX)

5. **Make a wall chart list of station titles.**
   Write the following list of the stations in large lettering on chart paper or a chalkboard to refer to throughout the session:
   A: Open-ended Exploration
   B: Structured Activity
   C: Problem-Solving Challenge
   D: Explaining

6. **Prepare salt water solution:**
   Fill a large plastic bucket with warm fresh water. While stirring, pour Kosher salt into the water until solution is saturated (won't dissolve any more salt crystals). Allow the solution to sit until water is no longer turbid. Use this solution for all stations of the activity.

The Day of the Session:

For the Ice Cube Investigation Activity Stations:

Set up the stations. Set up the three stations A, B and C by putting the materials (described under "What You Need" above) on a tray, with the instructions for that station. You will need to set up duplicate sets of these stations if you have more than 30 participants. The four stations are: Open-Ended Exploration; Structured Activity; and Problem-Solving Challenge.

Introducing the Topic of Educational Activity Approaches

1. **Get participants to begin thinking about the topic by asking thought-provoking questions.** Ask your participants to brainstorm different educational activity approaches/strategies that they may or may not have experienced themselves. For example: lecture, design activity, textbook, simulation, debate, "walk and talk" nature hike, exploration activity, etc. Have participants discuss the following question with the person sitting next to them for about two minutes:

   In your own education, what educational activity approaches do you remember responding best and worst to?

> **NOTE**: This presentation to workshop participants has been designed to "practice what we preach." The activity plan itself has been set up to reflect a learning cycle approach to instruction. Through the activity, the participants actually experience a version of the learning cycle instructional model as they learn about it. It is important that the session and presenter provide the opportunity for participants to experience each phase of the model for themselves—resisting the temptation to dole out too much information too early. Rather, the presenter should set up the circumstances and allow the participants to bring up most issues, while strategically inserting appropriate information to help clarify and organize the experience (and learning!) of the participants.

2. **Introduce the overall goals of the activity stations.** Point out that in this next part of the session, they will be rotating through three stations that represent different instructional approaches.

   a. Let them know that these stations have been specifically designed for adults, to stimulate discussion on how people learn, and how classroom learning can be structured. These activities are not meant to be presented to children or youth. Some of them may know a little or a lot about the subject area, but the purpose is for them to experience these stations as different approaches to teaching a topic of *any* kind.

   b. Emphasize that although one of their goals is to perform the assigned tasks, and get "caught up" in the activities themselves, the most important objective is to look at each station on a "meta-cognitive" level, that is to reflect on the learning experience. Encourage them to be aware of how they react personally to each approach, and how each stimulates, stifles, or in some other way impacts their learning.

3. **Introduce the station activities.** Explain that at each station they will:

   a. **Do the activity:** Work with a partner to read the signs and follow the directions. There will be a signal given when your time is almost up. You should expect to spend about eight to ten minutes at each station.

   b. **Clean up the station:** When you are finished, please clean up the materials before moving on to the next station.

Participants Rotate Through Stations

1. **Monitor station activities.** As participants work at the stations, check in with the groups to make sure they understand the directions, are making progress, and that they clean up the station before they move on.

2. **Announce time and rotate groups.** Keep an eye on the progress of groups at Station B. When most of them have finished both sides of their worksheet (after about eight to ten minutes), announce to the whole group that it is time to clean up and move on to the next station. Explain how they should rotate, with people from Station A moving on to Station B, Station B moving to Station C, and Station C moving to Station A.

3. **Use the Station D Explaining sheet to explain the phenomenon to group.** Tell them that station D is the *Explaining* station, and it will be done together with the whole group. Use the information on the Station D Explaining sheet to explain the phenomenon to the group.

Debrief of Station Activities

NOTE: For participants to feel comfortable sharing their own ideas in a discussion based on open-ended questions, it's important for the presenter to be accepting of all responses. The discussion may be much less effective if a hidden agenda emerges when the discussion leader responds in an accepting fashion to some comments while negatively to others. Also, in order to encourage participation from everyone rather than just a few more assertive participants, after asking a question, allow 3-4 seconds ("wait time") before calling on anyone.

The beauty of the discussion of the educational approaches is that participants bring up all the points, and the leader merely serves as facilitator of the discussion. Some background information for the discussion leader has been provided in the "script" of the activity. Although the "script" is provided as a guideline and framework, it should not simply be read off to participants. Rather, the skilled discussion leader should ask broad questions—which have no particular correct answer, and many of which are suggested in the script—and "flow" with the participants' responses and comments, while keeping the discussion generally on track and within schedule.

This may entail asking additional follow-up questions and inserting information we have provided as appropriate, as well as sharing some personal experiences of your own related to the topic. All of this should take place with the focus being on non-judgmental acceptance of the participant's comments and insights, while those of the presenter are judiciously sprinkled throughout the session—in non-lecture fashion. This kind of dynamic interchange cannot be fully scripted, and depends on the facilitation skills of the presenter. Like everything else, these workshop presentation skills can take time and practice to develop.

1. **Ask the participants to reflect on their responses to the activities and discuss the strengths and weaknesses of each approach.** Draw their attention to Station A, the Open-ended Investigation, and ask for their "metacognitive" reactions to the station. How did it make them feel? Did they learn from it? Be accepting of all responses. Be prepared for (and welcome) some disagreement. If only positive reactions to the station are brought up, ask if anyone had a negative reaction, and vice versa.

Point out that in this example, the Open-Ended Exploration station was intentionally unstructured in an *exaggerated* fashion, in order to provoke reaction and discussion. Exploration need not be completely unstructured, and more specific procedural directions, data recording charts and debriefing discussions can make it a more rewarding and educational experience for all learners.

Do the same debrief with stations B, C, and D. Give ample time for discussion of each station.

2. **Do a quick vote for favorite stations, and discuss participant preferences.** Ask participants to raise their hand for the station at which they felt most comfortable. Read the station titles and letters from the wall chart one at a time, and take a quick visual survey of the group's votes. Point out and discuss any interesting trends that may emerge in your group.

Tell them that different individuals often have different educational activity approach preferences, and although each of them or their particular group may (or may not) have a shared collective preference, others may have a different one. Note that these preferences may have to do with individual learning styles or with what educational activity approaches they've had most exposure to in the past.

3. **Ask participants to suggest some possible goals related to different educational activity approaches.** Point out that activity leader's choices for different approaches can often depend on the goals of the activity.

   Ask what goals each type of approach might serve. Use the following lists, not to read off item by item, but merely to supplement their discussion, if necessary.

   Open-Ended Exploration
   - Introduce children or youths to a new subject area
   - Generate questions
   - Generate children or youth interest and foster positive attitudes about science.
   - Encourage children or youths to work together without direct activity leader instruction
   - Develop and identify concepts, processes and skills, raise questions and problems.
   - Provide a common base of experiences.
   - Practice observation skills.

   Structured Activity
   - Introduce concepts, vocabulary, processes, skills, and investigation methods.
   - Guide children or youths toward specific discoveries.
   - Provide a common base of experiences.
   - Provide successful activities with predictable outcomes.

   Problem-Solving Challenge
   - Model what scientists do.
   - Provide a sense of accomplishment.
   - Challenge children or youths' conceptual understanding and skills by applying them to new situations.
   - Develop deeper and broader understanding through real world applications.

Explaining

- Provide specific content information and vocabulary on a topic.
- Extend the information from an activity into descriptions of related experiences that are impractical in a classroom setting.
- Provide alternative explanations and make connections into other subject areas.

Point out that choices of educational activity approaches also depend on available time, home and educational program culture, and the previous experiences of the audience and the activity leader. Some groups (and individuals) need more guidance, and others need more time to explore.

5. **Discuss the sequence of stations.** In the previous discussion, points about participants' preferred order of stations may have already arisen. Point out that each group rotated through the groups in a different sequence. Ask if they like the order they did them in, or if there is a different order they think would have suited them better or been more effective.

6. **Introduce the Learning Cycle**. When faced with a new experience or learning situation, how do people tend to approach and successfully integrate its activities into useful knowledge? How do people learn? One instructional model has gained wide acceptance as a useful way to look at the phases in how people learn. This model has often been called "the learning cycle." It is based on educational research on common components of good instructional models, as well as the work of cognitive scientists and classroom-based researchers who study teaching and learning. In the early 1960s scientists and education researchers who were dedicated to designing science and mathematics activities that were much more educationally effective and better aligned with the learning process began using the learning cycle model to help guide their educational activity development.

Sidebar on the 5 E's: Engagement, Exploration, Explanation, Elaboration and Evaluation. And David Kolb's (1984) Experiential Learning Model: Concrete experience, Reflective observation, Abstract conceptualization and Active experimentation. (Referred to in "Learning is About Making Connections" by K. Patricia Cross.) Also "Common Components shared by Instructional Models from "Inquiry and the National Science Education Standards" page 35, and the chapter entitled Improving Instruction in "Achieving Scientific Literacy: From Purposes to Practices" by Roger Bybee (1997).

7. **Show the *Learning Cycle* overhead transparency, and describe each phase.**

Invitation: An invitation is a question, problem, observation or demonstration that initiates the learning task. It should make connections between past and present learning experiences, anticipate activities and organize children or youths' thinking toward the learning outcomes of current activities. If learners are not engaged, it is probable that only rote learning will take place, which has much poorer retention.

Exploration: Open-ended exploration of real phenomena, discussion about their discoveries, ideas, and questions that arise. Can be hands-on or more abstract.

Concept Invention: With interest and attention focused, concepts, or methods to solve problems and construct new meanings, are invented by the learners or introduced by the instructor.

Application: Armed with new ideas, apply new knowledge and abilities to different situations.

8. **Connecting the structure of this session with the learning cycle model.** Draw participants' attention to the elements of this activity that fit with the learning cycle model.

   Invitation: The initial questions posed at the beginning of the activity.
   Exploration: The station activities and discussion.
   Concept Invention: The introduction to the learning cycle model.
   Application: The current and following activities. Further applications will occur when they apply the learning cycle to different activities in the future.

   Point out that you *could* have started the activity by skipping the exploration and invitation phases and moving immediately to concept invention. Ask them how their experience would have been different had the activity begun with the introduction of the learning cycle without the station activities and discussion.

9. **Putting the Learning Cycle to use in educational settings.** Point out that the learning cycle approach can be an extremely valuable tool for designing educational activities. When an educational activity is ineffective, it's often because concepts and vocabulary have been introduced *before* exploration. The children or youth aren't interested yet, and have little context for the concepts. Some otherwise great activities lack an application opportunity, which can result in low retention. Sometimes children or youth are given the opportunity to explore but aren't ever provided with concept invention, which is a missed opportunity.

   An internalized learning cycle model is an excellent activity-planning tool—*and* it can also help guide the many on-the-spot decisions activity leaders must make in any given activity.

   Using the learning cycle as a *flexible* tool. Every successful activity need not include all stages of the cycle. There may be cycles within cycles in one activity, or just one or more stages of a cycle in an activity. Sometimes, though not usually, children or youth may have explored a subject amply before coming to class and be ready to enter the cycle at the concept invention phase right away.

   The detrimental focus on only one phase of the cycle. Many activity leaders' activities suffer as a result of a focus on only the one phase of the cycle with which they feel most comfortable. For example, many activity leaders spend most of their time with concept invention. It can also be detrimental to focus solely on exploration, when other stages are neglected or rushed.

Modeling a Learning Cycle-Based Activity

Start the Model Activity

Present the model activity you have chosen. Tell the participants that you'll be presenting an activity that embodies the learning cycle. At the conclusion of the activity, you'd like them to share their ideas of how the different phases of the learning cycle relate to this activity. Present the activity you have chosen.

Debriefing the Learning Cycle-Based Activity

1. **Ask participants to note the stages of the learning cycle in the activity just presented.** For example, following is a suggested outline of the learning cycle stages of *Fingerprinting,* from the *GEMS Crime Lab Chemistry* unit.

   Invitation: Questions to elicit interest and curiosity: "What are fingerprints?" " What do you know about fingerprints?" Have you ever been fingerprinted?"
   Exploration: Children or youth make their own fingerprints, look at them, notice patterns, then group and name them in their own way. Look at 10 new prints.
   Concept Invention: The standard classification system (arch, loop, whorl) is introduced.
   Problem-Solving Challenge: Children or youths classify their own fingerprints using standard system.

   OPTIONAL: Children or youth further apply what they've learned to a mystery scenario ("Who Robbed the Safe?")

2. **Explain that without the opening invitation and free exploration, children or youth have had no opportunity to become interested in and develop the concepts for themselves**, before the conceptual content is introduced. It introduces information which children or youth have not thought about and are not interested in, and steals the fun of discovering the concept.

3. **Point out that it is very common for science activities to be presented in a non-learning cycle-based way.** Typically an activity leader introduces several concepts and some new vocabulary, and then instructs children or youths to follow a procedure through which those concepts are demonstrated or verified. Share how easy it is to reformat "traditional" science activities to follow a more effective learning cycle approach. If you have time, ask participants to reformat a hypothetical activity.

4. **Close by emphasizing that the learning cycle model is not meant to be viewed in a mechanical or lockstep fashion.** As they will see as they learn and present different science activities, there is no one correct sequence, and it is important to be flexible, depending on specific content, children's or youth's experience and level, and many other factors. Rather than a closed circle, it is more fitting to see the learning cycle as an ongoing spiral. Even as one question is investigated, many new questions arise.

Slide 1

Learning Cycle:

Invitation

Exploration

Application

Concept Invention

Invitation—Children or youth are offered a question or a problem to solve, they make an observation or watch a demonstration, can also be a hands-on experience which sets the stage for learning.
Exploration—Open-ended exploration of real phenomena, followed by a discussion about discoveries, ideas, and questions that arise.
Concept Invention—After interest and attention is focused, learners invent, or activity leader introduces information, concepts, or methods to solve problems, to help construct new meanings.
Application—Armed with new ideas, children or youth apply this knowledge and skills to solving a problem or meeting a challenge.

Learning Cycle ***Take-Home Sheet***

Invitation

Exploration

Application

Concept Invention

Invitation – Initiates the learning task. Should make connections between past and present learning experiences, generate anticipation of content to be explored, and begin to focus/organize learner's thinking toward the learning outcomes of the upcoming activities.

Activity leader's Role:
Create interest and generate curiosity. Raise questions and problems. Elicit responses that uncover learner's current knowledge about the concept/topic.

Exploration – Involves open-ended exploration of real phenomena, followed by discussion about learner's discoveries, ideas, and questions that arise. Provides a common base of experiences for learners to develop current concepts, skills and processes.

Activity leader's Role:
Encourage learners to work together without direct instruction from the activity leader. Observe and listen to learners as they interact. Ask probing questions to redirect learner's investigations when necessary. Provide time for learners to puzzle through problems. Act as a consultant for learners.

Concept Invention - After interest and attention is focused, learners invent, or activity leader introduces concepts and/or methods to solve problems, which enable the learners to construct new meanings.

Activity leader's Role:
Encourage children or youths to explain concepts and definitions in their own words. Ask for justification (evidence) and clarification from children or youths. Provide formal definitions, explanations, and new vocabulary. Use children or youths' previous experiences as the basis for explaining concepts.

Application —Armed with new ideas, learners apply new knowledge and skills to solving a problem or meeting a challenge. They develop deeper and broader understanding, gather more information and develop skills.

Activity leader's Role:
Provide opportunities for learners to use vocabulary, definitions, and explanations in a new context. Encourage learners to apply the concepts and skills in new situations. Remind learners of alternative explanations. Evaluate progress of learners.

Station A: Open-ended Investigation

Examine the materials on the tray. Using only those materials, devise experiments you can perform to learn as much as you can about:

- the characteristics of warmer vs. cooler water;
- the characteristics of salty vs. fresh water;
- the relative densities of different temperatures and salinities of water;
- density-driven currents in the ocean.

And remember, this is a science activity—no tasting!

Station B: Structured Activity

Follow the procedures described on the worksheet provided. You are allowed to work as a group to conduct the activity and to arrive at your answers.

Instructions and Worksheet for Station B

Structured Activity

1. Find two beakers of water on the table. One is labeled "salt water," the other is labeled "fresh water."

2. If you place the same number of ice cubes in each cup at the same time, which do you predict will melt the fastest?

   Why?

3. Now place three ice cubes in each beaker of water. Observe both for 90 seconds.

4. Which ice cubes melted the fastest?

5. Do you have any further explanation to match your evidence?

6. Gently add 4 drops of food coloring to each beaker. Describe your observations.

7. Can you explain what is happening?

Station C: Problem-Solving Challenge

There are two beakers of water on the table. One contains salt water, the other fresh water. Using only the materials at the table, can you devise an experiment that you can perform right now that will reveal which is the salt water? Record your experiment (design, procedures) and the results. Describe the evidence that you collect and how it supports your determination of which is the salt water.

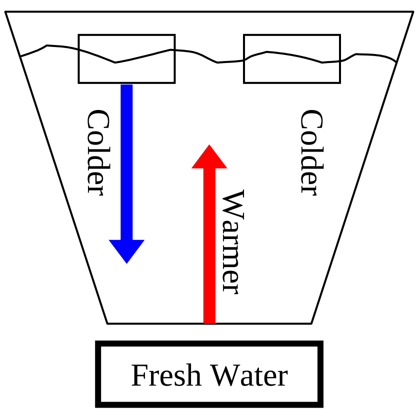
Oh, and by the way, no tasting allowed!

Station D: Explaining

Explain to the whole group why the ice cubes melt more slowly in the salt water. Either read the information written below aloud, or explain it in your own words, while making diagrams on the board.

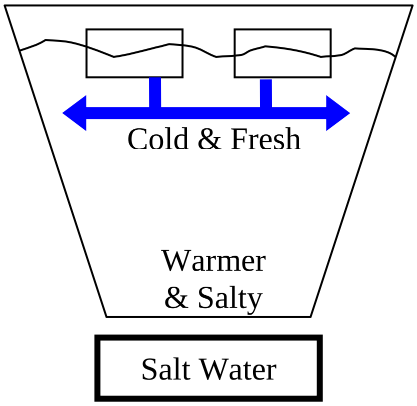
What's going on with the ice in fresh water?

Cold water is more dense than room temperature water. The ice cubes are frozen fresh water. When the ice cubes are placed in fresh water, the cold melted fresh water mixes easily with the room temperature fresh water in the cup because the denser cold water from the melting ice sinks to the bottom of the cup. The food coloring makes it so you can see how this water is moving. When the dense cold water sinks to the bottom, it forces room temperature water at the bottom to move up toward the surface. Because the water in this container is constantly mixing, the ice cube is always being surrounded by new room temperature water, so the ice cube melts fairly quickly.



What's going on with the ice in salty water?

Salt water is more dense than fresh water. A liquid that is less dense will form a layer on top of a liquid that is more dense. As the ice cubes in the salt water melt, the cold melted freshwater forms a layer on top of the salt water, because the salt water is more dense. The food coloring makes it so you can see this layer. Fresh water is always less dense than salt water no matter what the water temperature is. The layer of cold water from the melting ice insulates the ice. In other words, the cold, fresh water from the melting ice helps keep the ice cold. That's why the ice melts more slowly in salt water.



How does this relate to the ocean?
In the ocean, layers of water of different densities form. The density of the water is mostly determined by its temperature, and how salty or fresh it is. Cold, salty water is more dense than warm fresh water.

One example in nature of density layers forming, as in the cup with the salt water is the ocean near the mouth of the Amazon river. The less dense warm fresh water forms a layer on top of the colder salty ocean water many miles out to sea.

An example in nature of mixing of higher density water sinking down and mixing with lower density water, as in the cup with the fresh water, is a the ice at the surface of a lake that has frozen over as the ice is melting. The cold ice water is more dense than the warmer water below, so it sinks and mixes in, which makes the ice melt faster.

PART 4:
About Science and Engineering in Out-of-School Programs

The Difference Between Design Challenges and Science Explorations

What Is Design?

Design is a term and process associated with a wide variety of professions and occupations. There are graphic designers, product designers, fashion designers, interior designers, and architects, as well as painters and sculptures who work in design. This project focuses on engineering design. All of these fields of work have procedures and practices in common, often characterized as follows:

- Identify and define problems
- Gather and analyze information
- Determine performance criteria for successful solutions
- Generate solutions and build prototypes
- Evaluate and select appropriate solutions
- Implement choices
- Evaluate outcomes

These procedures are characteristics of an overall process, which takes many forms and is not necessarily carried out in a step-by-step, systematic, linear manner. *Design It!*, written by Education Development Center, Inc., is an example of a design engineering program developed for children and youth in informal learning environments. Within this program, there is only an approximation of these characteristic features. Each project is more like a type of guided design where the overall challenge and problem has been decided for the children and some of the criteria are already defined. However, there is still a lot of room for children to generate solutions and evaluate the results. There are also opportunities to expand on the suggested activities.

It is important to recognize that the engineering design process is different from what is called the "scientific method." Design is about applying scientific and practical knowledge to solve problems. In a rough characterization, scientists working within the scientific method are concerned with finding patterns, analyzing data, proposing explanations, and developing and using abstract concepts. Architects, engineers, and graphic artists, on the other hand, are more concerned with defining problems and synthesizing available information to solve these problems. Often, engineers will use scientific concepts and procedures to design and arrive at workable solutions. However, the overall goal is different for the engineer than for the scientist. In recent years, the process of inquiry has become strongly associated with the teaching of science in both formal and informal environments.

Design and inquiry share some common features but, overall, are different processes. For young children, it is perhaps not critical to make much of a distinction between these two processes; there is a back and forth interaction between making discoveries and immediately applying those discoveries to solve problems in children's constructions. Most of this happens in a highly intuitive manner. However, it is important for activity leaders to keep in mind that the overall goal and focus of design-challenge projects is to provide opportunities for children to develop problem-solving strategies and skills. Thus, attention should be given more to helping children find solutions than to having them explain why something functions the way it does.

For example, finding the best combination of rubber bands and wheels to get a model car to travel a long distance is more important than spending time to study the forces needed to make an object move. Reflective discussions are focused on the process by which children arrive at solutions rather than, for example, how the rubber band is an example of potential energy that can be converted into kinetic energy of a moving model car. This does not mean that time cannot be spent on developing a scientific understanding of the systems the children are investigating, but that higher priority is given to the manner in which problems are solved.

Why Design Engineering Activities?

Many children have a natural tendency to assemble, build, and play with devices of their own design. They also like to be challenged with projects that allow them to develop new skills and create new devices. In recent years, a variety of programs, both in school and out of school, have been developed around engineering design projects. These have proved to be very popular and have won wide attention, but most have been developed for older youth. Some of these are structured as highly competitive undertakings, which result in only a small number of participants. Another approach is to present design challenges that engage the attention of a wider group. The competitive element is downplayed, cooperation is emphasized, and children of varying abilities are encouraged to participate. It has been demonstrated in schools in the United States and especially in England that younger children will participate in these kinds of projects enthusiastically and produce impressive results. Most of these projects are a meaningful context for developing basic skills and conceptual knowledge. The *National Science Education Standards* (NSES) of the National Research Council (1996) and the *Standards for Technological Literacy* of the International Technology Education Association (2000) have specifically targeted design and technology as important areas for students to have some understanding.

The Relationship Between Play and Exploration

When observing children manipulate materials, adults often categorize this type of behavior as play, without distinguishing play from exploration. Research done in the 1960s and 1970s suggests that these two kinds of behaviors are indeed different. Studying the behavior of animals and young children, researchers found that there was a back-and-forth between two kinds of behavior, which were clearly but subtly different. These could be characterized by two questions the animal or child might be asking: What does this object do? and What can I do with this object? If a child is asking the first question, he or she might manipulate the object or material to discover its properties. The question might be, for instance, How does a ball roll down, and then up, a U-shaped track? or What kinds of bubbles can I make? We could characterize such a mindset and behavior as "exploration." If a child is asking the second question, he or she might make up a game or pretend that the object or material represents something else. The implicit question might be: How can I make up a game where balls bump into each other and points are given for guessing what will happen? Or Let's pretend that the small marble is a motorcycle and the bigger marble is a truck; what happens when the truck crashes into the marble? In the latter examples, the child's attitude toward the object or material can be characterized as a "play" frame of mind. The dictionary defines exploration as "a careful search for information." Play has multiple definitions, mostly associated with games and recreation.

It is often assumed that children already know much about the familiar toys and objects of the world. For instance, blowing bubbles has been a pastime for many years and continues to be an activity many children enjoy. One might assume that because children have blown bubbles a few times, they have picked up knowledge about some of the properties of soap film. What becomes clear during activities where children are using bubbles is that children have not previously noticed properties such as the fact that soap film has a tendency to shrink and to take on geometric configurations. A more focused and sustained series of activities can make these properties more visible to the children and bring about a greater conscious awareness of them. As they try their hand at making bubbles of different sizes and shapes, children can also invent competitions and games: Who can make the biggest hemispherical bubble on the tabletop? What kind of animal shapes can be made with groups of small bubbles? Exploration and play can be readily mixed and integrated.

Out-of-school programs may want to provide a structure where this back-and-forth between play and exploration can happen. However, it may seem contradictory to the activity leader to associate structure with the behavior of play or of exploration. Play, especially, is associated with freedom from restraints. Yet, most games have rules and boundaries. Within these constraints, a variety of movements, actions, manipulations, and exercises of the imagination are possible. Part of the fun of play is to see what one can do within certain constraints. The content and sequence of activities in some curriculum units have been designed so that there is manageable complexity. New materials or new problems move the overall project forward and stimulate further involvement. But, so that children do not become overwhelmed, they are presented in a way that provides continuity and a structure for building comprehension of the phenomenon being investigated.

Resource List/References
<to be added>

