

Participant's Manual

Designing Effective Science Lessons

BUILDING THE FRAMEWORK

By Jan Tuomi & Anne Tweed
with Heather Hein



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Building the Framework

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INTRODUCTION

Notes:

Welcome to *Designing Effective Science Lessons (DESL)*. We're looking forward to working with you to improve science education in your classroom. The strategies and advice in these professional development sessions have been carefully selected as the very best, based on the research available – which means your work to implement new methods will be worth the effort. And we'll explore each new strategy in enough depth that you should be able to keep up the momentum and start implementing improvements when you return to the classroom. We planned each step with your success in mind.

Purpose and Outcomes of *DESL*

Designing Effective Science Lessons is an eight-day professional development program that empowers teachers to make immediate and steady improvements to their science instruction in grades K–12. At the core of the program are research-based strategies that have been positively associated with improved student achievement. As a result of the eight-day *DESL* program, you will be able to:

- Examine critically the approaches you currently use to teach science
- Compare elements of your science lessons to those elements that research shows to be highly effective
- Identify areas of your instructional practices which need improvement
- Put to work immediately specific skills and strategies in the classroom, focusing on the identified areas
- Come away with practical steps for taking charge of your own future professional development

DESL targets three essential components of lesson planning:

- Identifying Important **Content**
- Developing Student **Understanding**
- Creating a Learning **Environment**

The authors of the *DESL* manuals, after reviewing the research on effective science lessons, came to the conclusion that focusing on these three essential elements will increase overall lesson quality. This is the three-part C-U-E framework at the heart of *Designing Effective Science Lessons*. You will learn how best to put these components to work in your own classroom so that you can deliver lessons of exceptional quality and, ultimately, improve outcomes for your own diverse learners.

Notes: **How *DESL* Is Organized**

DESL is most effective when delivered as a four-part professional development program:

1. Building the Framework (two days)
2. Identifying Important Content (two days)
3. Developing Student Understanding (two days)
4. Creating a Learning Environment (two days)

The four sessions are delivered over a period of 4–10 months, interspersed with opportunities to implement the recommended strategies.

Session 1 provides the foundation for the more advanced sessions. You will reflect on high-quality lesson planning and be introduced to the C-U-E strategies, which you will apply to your lessons later.

Sessions 2, 3, and 4 broaden your understanding of each area and allow you to apply *DESL* to specific science lesson plans. You will create or revise lessons during the professional development sessions, which provide time for immediate practice and application of the recommended strategies.

The format of the sessions is designed to present new information and then provide opportunities for you to explore, practice, discuss, and personalize the information. Frequently, you will be asked to reflect on current practice, contemplate possible changes, and plan steps to take upon return to the classroom. The format of each strategy includes three sections:

What the Research Says

After a thorough review of the research on science instruction, the authors chose strategies which teachers can implement in their classrooms right away to increase student achievement. This section identifies the research on which the strategies are based and the implications of that research for teachers.

Exploring Effective Strategies

To ensure an understanding deep enough to begin use, each strategy is modeled and then practiced or discussed. These experiences will support the role of each participant as a reflective learner.

Planning for Classroom Implementation

Self assessment and personalized planning tools help meet a range of teachers' needs – including motivation, support and identification of resources – to continue and expand ongoing professional development. You are encouraged to apply the strategies learned as you revise a personal unit of study.

DESL Participant's Manuals

The *DESL* Participant's Manuals are designed to accompany the *DESL* professional development program. During the sessions, the manuals provide room for notes to accompany background information. In addition, the manuals provide directions for all activities, references, and, in sessions 2, 3, and 4, reproducible templates.

Outcomes of Building the Framework

As a result of this first session, you will

- Become aware of current research and information on the quality of science lessons
- Learn about the *DESL* three-part framework
- Understand the first strategies for Content, Understanding, and Environment

Notes:

EXPLORING EFFECTIVE SCIENCE LESSONS

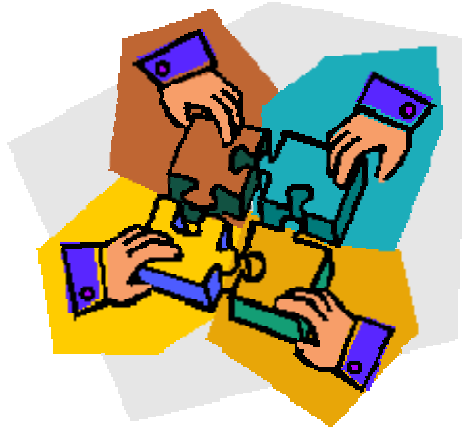
Notes:

This section introduces recent research on the effectiveness of science instruction in classrooms across the United States. This information provides the foundation for the recommendations that follow as well as detailed definitions of quality and effectiveness.

In this section, you will focus on

- The research behind effective science lessons
- Lesson strengths and weaknesses
- Setting goals
- Understanding how people learn

Warm-Up Activity: Jigsaw Puzzle



Discuss with a small group: In what ways is a jigsaw puzzle like a high-quality science lesson?

Notes:

The Quality of Science Lessons

This section introduces recent research on the effectiveness of science instruction in classrooms across the United States. This information provides the foundation for the recommendations that follow, as well as detailed definitions of quality and effectiveness.

The basis of many *DESL* recommendations comes from *Looking Inside the Classroom: A Study of K–12 Mathematics and Science Education in the United States* (Weiss, Pasley, Smith, Banilower & Heck, 2003), a report from Horizon Research, Inc., which provides many insights about the nature and quality of current K–12 science education.

Using a 1–5 scale, 1 being ineffective instruction and 5 being exemplary instruction, the study rated four key components of instruction:

- Lesson design
- Implementation
- Science content
- Classroom culture

What do you predict the research says about the quality of science lessons?

Making Predictions

Record your prediction of what the research says about science lessons at the elementary, middle, and high school levels. What percentage falls into each category?

How likely is a science lesson to be rated high, medium, or low in quality?			
	Elementary	Middle School	High School
% High Quality			
% Medium Quality			
% Low Quality			

Discuss your predictions with others in your small group. How did your predictions differ from others?

Notes:

Notes: Now, record the actual percentages for science classrooms in the Horizon Research study.

How likely is a mathematics/science lesson to be rated high, medium, or low in quality?			
	Elementary	Middle School	High School
% High Quality			
% Medium Quality			
% Low Quality			

Compare your group predictions with the actual numbers. What are your initial reactions?

Four Elements of Quality and Their Indicators

According to the Horizon Research study, four elements are essential to delivering high-quality science instruction. Deficits in any one of these areas will decrease the efficacy of a science lesson as a whole. Looking at these four areas and their indicators of quality can help you better evaluate your own lessons.

- **Lesson design** consists of planning, instructional strategies, assigned roles, and resources used for the lesson.
- **Implementation** includes pacing, classroom management, teacher questioning, and teacher confidence.
- **Science content** refers not only to the importance and grade-level appropriateness of the material being taught but also to student engagement in and sense-making of the content.
- **Classroom culture** includes the encouragement of active participation, quality of teacher-student and student-student interactions, and constructive feedback.

On the following page, read the indicators of quality for these four areas. Then, answer the questions to reflect on the quality of your lessons.

Notes:

Four Elements of Quality and Their Indicators

Lesson Design	Implementation
• Available resources contribute to accomplishing the purpose of the instruction. • Lesson reflects careful planning and organization. • Strategies and activities reflect attention to students' preparedness and prior experience. • Strategies and activities reflect attention to issues of access, equity, and diversity. • Lesson incorporates tasks, roles, and interactions consistent with investigative science. • Lesson encourages collaboration among students. • Lesson provides adequate time and structure for sense-making. • Lesson provides adequate time and structure for wrap-up.	• Teacher appears confident in ability to teach science. • Teachers' classroom management enhances quality of lesson. • Pace is appropriate for developmental levels/needs of students. • Teacher is able to adjust instruction according to level of students' understanding. • Instructional strategies are consistent with investigative science. • Teacher's questioning enhances development of students' understanding/problem solving.
Science Content	Classroom Culture
• Content is significant and worthwhile. • Content information is accurate. • Content is appropriate for developmental levels of students. • Teacher displays understanding of concepts. • Elements of abstraction are included when important. • Students are intellectually engaged with important ideas. • Appropriate connections are made to other areas. • Subject is portrayed as dynamic body of knowledge. • Degree of sense-making is appropriate for this lesson.	• Climate of respect for students' ideas, questions, and contributions is evident. • Active participation of all is encouraged and valued. • Interactions reflect working relationship between teacher and students. • Interactions reflect working relationships among students. • Climate encourages students to generate ideas and questions. • Intellectual rigor, constructive criticism, and challenging of ideas are evident.

Note: Adapted from *Looking Inside the Classroom: A Study of K-12 Mathematics and Science Education* (pp. 29-38) by I. Weiss, J. Pasley, S. Smith, E. Banilower, E., & D. Heck, 2003, Chapel Hill, NC: Horizon Research, Inc. Copyright 2003 by Horizon Research, Inc. Adapted with permission.

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IDENTIFYING IMPORTANT CONTENT

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Identifying Important Content

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INTRODUCTION

Notes:

Welcome to *Designing Effective Science Lessons: Identifying Important Content*. This session focuses on helping teachers choose content that is significant, rigorous, and appropriate for science classrooms. Content is the first of our three-part framework – the next session will focus on developing student understanding, and the final session will focus on creating a learning environment in your classroom. The authors of this manual, after reviewing the research on effective science lessons, came to the conclusion that focusing on these three essential elements is a strategy that will increase overall lesson quality. This is the C-U-E framework at the heart of *Designing Effective Science Lessons*: rigorous content, instruction that develops understanding, and an environment centered on learning.

In the Building the Framework session, you were introduced to the first of six strategies for identifying important content. This session will build on the first strategy and cover the remaining five. The following table provides an overview of all of the strategies. Remember, the strategies help to keep focused on the question, “Why am I doing this?”

Session 2 : Identifying Important CONTENT	
Identify “big ideas,” key concepts, knowledge and skills that describe what the students will understand. <i>Begun in Session 1</i>	Why Am I Doing This?
Prune extraneous sub-topics, technical vocabulary and wasteful repetition.	
Create essential questions that engage students with the content.	
Identify common preconceptions and prior knowledge.	
Develop assessments that correlate to the conceptual understanding and related knowledge and skills.	
Clarify and sequence learning activities to focus instruction on conceptual understanding.	

As a result of this session, you will

- Understand the above strategies for identifying important content
- Apply these strategies to your own units
- Improve the quality of your science lessons on your own and immediately

Notes:

How *DESL* Is Organized

We will begin with a review of the first session. Following the review, we will present new strategies in a format which gives information and then provides opportunities for you to explore, practice, discuss, and personalize the information.

Frequently, you will be asked to reflect on current practice, contemplate possible changes, and plan steps to take upon your return to the classroom. The format of each strategy includes three sections:

- **What the Research Says**

After a thorough review of the research on science instruction, the authors chose strategies which teachers can implement in their classrooms right away to increase student achievement. This section identifies the research on which the strategies are based, and the implications of that research for teachers are discussed.

- **Exploring Effective Strategies**

To ensure an understanding deep enough to begin use, each strategy is modeled and then practiced or discussed by participants. These experiences will support the role of each participant as a reflective learner.

- **Planning for Classroom Implementation**

Self assessment and personalized planning tools are provided to help meet a range of teachers' needs – including motivation, support and identification of resources – to continue and expand professional development. You are encouraged to apply the strategies learned as you revise a personal unit of study.

Identifying Important Content is the first of our three-part framework for designing effective science lessons. The following tables preview upcoming strategies for *Developing Student Understanding* and *Creating a Learning Environment*.

Session 3: Developing Student UNDERSTANDING

Engage students in science inquiry to develop understanding of science concepts and the nature of science. *Begun in Session 1*

Make use of formative assessments throughout a unit to measure student progress towards understanding.

Build on prior knowledge and address preconceptions.

Provide daily opportunities for wrap-up that support student sense-making.

Develop student understanding through collaborative science discourse.

Teach concepts in depth by allowing students to continually refine their understanding through practice, review, and revision.

Session 4: Creating a Learning ENVIRONMENT

Show through your actions that you believe all students have the ability to learn. *Begun in Session 1*

Teach students to think scientifically.

Develop positive student attitudes and motivation to learn science.

Give timely and criterion-referenced feedback.

Keep students focused on learning by reinforcing progress and effort.

Involve students in assessing their own progress.

REVIEW OF SESSION 1: CONTENT

Warm-Up Activity: Who Started It?

Before you can change how you do things in your classroom, you need to decide to stop doing what you're doing now. It's also important to realize that you do not teach and make these decisions in a vacuum – everyone in a school is, to some extent, modeling the behavior of others.

How to Play the Game

1. Get into a circle and start pointing at anyone across from you in the circle. That person must now point to someone else across the circle, who then must point to another person, etc. Only point at someone who is not being pointed at. Carry on until everyone is pointing at someone, with no two people pointing at the same person.
2. Now, fix your eyes on the person you just pointed at. Keep watching that person, as he or she will now be your Role Model.
3. You have only one job: to watch your Role Model closely and copy his or her actions. The only time you may move is if your Role Model moves. In fact, if the Role Model does anything — coughs, twitches a finger, etc. — you must repeat that motion once, and then be still again.
4. Continue for 4–5 minutes.

Debriefing Questions

- What happened?
- Could you tell who started some of the movements?
- How did this game model what happens to teachers in their everyday lives?

In the context of our work on *Designing Effective Science Lessons*, how might we change what we are doing already to become more effective and improve the quality of the science lessons in our classrooms? Talk to one other person about what happened during the opening activity.

Notes:



Notes:

Review of Research Background

Let's begin by reviewing what we learned in the first session about the research background which supports identifying important content and the resulting strategies.

1. Teachers often try to teach too much and there isn't enough time for students to learn everything (Stigler & Hiebert, 1998).

Teachers can unburden their curriculum by

- Cutting major topics
- Pruning subtopics from major topics
- Trimming technical vocabulary
- Reducing wasteful repetition

(American Association for the Advancement of Science, 2000)

2. Teachers must clearly identify learning goals for students. Setting objectives and providing feedback will result in a 23-percentile gain in student achievement.
 - Instructional goals narrow what students focus on.
 - Instructional goals should not be too specific.
 - Students should be encouraged to personalize the teacher's goals. (Marzano, Pickering & Pollock, 2001)
3. By taking the time to study a topic before planning a unit, teachers build a deeper understanding of the content, connections, and effective ways to help students achieve understanding of the most important ideas and skills (Keeley, 2005).
4. Don't overestimate what students can learn at a given age or underestimate what they can learn at any age (American Association for the Advancement of Science, 1993).
5. Assessing for prior knowledge and preconceptions must occur to make certain that the content being taught is appropriate for students.

"Students come to the classroom with [preconceptions] about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their [preconceptions] outside the classroom" (Bransford, Brown & Cocking, 2000, pp. 14-15).
6. The standards themselves are not the curriculum. Standards and science frameworks must be unpacked so that the appropriate concepts are taught at each grade level. Teachers must know how the understanding of concepts develops as part of a learning trajectory. Expert teachers
 - Know the structure of the knowledge in their disciplines
 - Know the conceptual barriers that are likely to hinder learning

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DEVELOPING STUDENT
UNDERSTANDING

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Designing Effective Science Lessons

Developing Student Understanding

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INTRODUCTION

Notes:

Welcome to *Designing Effective Science Lessons: Developing Student Understanding*. This third *DESL* session focuses on working with your students to develop their understanding of science concepts. In session 2, we learned about identifying the right content and, in session 4, you will learn about creating a learning environment in the classroom. The authors of this manual, after reviewing the research on effective science lessons, came to the conclusion that focusing on these three essential elements is a strategy that will increase overall lesson quality. This is the C-U-E framework at the heart of *Designing Effective Science Lessons*: rigorous *content*, instruction that develops *understanding*, and an *environment* centered on learning.

In the first session, Building the Framework, you were introduced to the first of six strategies for developing student understanding. This session will build on the first strategy and cover the remaining five. The following table provides an overview of all of the strategies. Remember, the strategies help you focus on the question, “Who’s working harder?” Your lessons should be structured such that the answer is, “The students!”

Developing student UNDERSTANDING	
Engage students in science inquiry to develop understanding of science concepts and the nature of science. <i>Begun in Session 1</i>	Who’s working harder?
Make use of formative assessments throughout a unit to measure student progress towards understanding.	
Build on prior knowledge and address preconceptions.	
Provide daily opportunities for wrap-up that support student sense-making.	
Develop student understanding through collaborative science discourse.	
Teach concepts in depth by allowing students to continually refine their understanding through practice, review, and revision.	

As a result of this session, you will

- Understand the above strategies for developing student understanding and apply them to your own classroom
- Improve the level of understanding in your classroom and the quality of your science lessons, in general

How *DESL* Is Organized

We will begin with a review of the first session. Following the review, we will present new strategies in a format which gives new information and provides opportunities for you to explore, practice, discuss, and personalize the information.

Notes:

Frequently, you will be asked to reflect on current practice, contemplate possible changes, and plan steps to take upon your return to the classroom. The format of each strategy includes three sections:

- **Analyzing What the Research Says**

After a thorough review of the research on science instruction, the authors chose strategies which teachers can implement in their classrooms right away to increase student achievement. This section identifies the research on which the strategies are based and the implications of that research for teachers.

- **Exploring Effective Strategies**

To ensure an understanding deep enough to begin use, each strategy is modeled and then practiced or discussed by participants. These experiences will support the role of each participant as a reflective learner.

- **Planning for Classroom Implementation**

Self assessment and personalized planning tools are provided to help meet a range of teachers' needs – including motivation, support and identification of resources – to continue and expand professional development. You are encouraged to apply the strategies learned as you revise a personal unit of study.

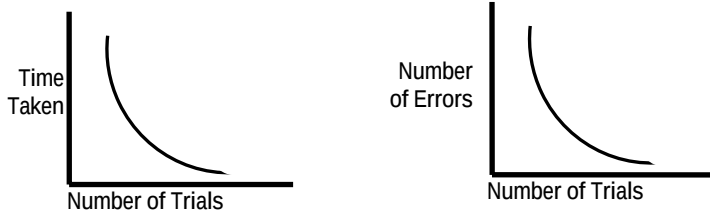
Developing Student Understanding is the second of our three-part framework for designing effective science lessons. In the fourth session, you will learn how to create an environment in your classroom that supports learning. The following table previews the upcoming strategies.

Creating a Learning Environment
Show through your actions that you believe all students have the ability to learn. <i>Begun in Session 1</i>
Teach students to think scientifically.
Develop positive student attitudes and motivation to learn science.
Give timely and criterion-referenced feedback.
Keep students focused on learning by reinforcing progress and effort.
Involve students in assessing their own progress.

REVIEW OF SESSION 1

Warm-Up Activity: The Puzzle of Learning

Before we can learn anything, we must be able to think about the problem or the concept and make sense of our observations. As early learners, we often solve problems using a trial-and-error learning approach. According to Thorndike (1898), this is a gradual reduction in the numbers of errors made in pursuit of a goal. The more times a problem is encountered, the less time it takes to solve and the fewer the number of errors are made. This information can be plotted on learning curves.



Instructions: Each person will receive four identical puzzle pieces (see Appendix). These four pieces can be put together to form a square. Everyone should try to solve the puzzle; your effort on this task will be timed. The square when completed does not have a hole in the middle.

Continue as long as it takes to complete the task. If you complete the square, record the time and then mix up the pieces and complete a second trial and time that attempt, also. When you complete the puzzle a second time, mix up the pieces one final time and then reconstruct the puzzle a third time, recording the time it takes to complete the square.

Debriefing Questions

1. How persistent were you in solving the problem?
2. What was your response when you discovered that others could solve the problem faster or slower than you did?
3. What did you learn during the activity? What strategies would have helped you to learn how to solve the problem?
4. What strategies can teachers use to help students that are struggling with a science concept?

In the context of our work on *Designing Effective Science Lessons*, how might we change what we are doing already to become more effective and improve the opportunities for our students to learn and understand important science concepts? Talk to the people in your group about what happened during the opening activity.

Notes:



Notes:

Review of Research Background

Let's begin by reviewing what we learned in the first session about the research which supports an inquiry approach to student understanding of science concepts.

- Inquiry helps students develop:
 - An understanding of science concepts
 - An appreciation of “how we know” what we know in science
 - An understanding of the nature of science
 - Skills necessary to become independent inquirers about the natural world
 - The disposition to use the skills, abilities, and attitudes associated with science*National Science Education Standards* (National Research Council, 1996)
- Understanding science is more than knowing facts. Through scientific inquiry, students can:
 - Gain new data to change their ideas
 - Deepen their understanding of important scientific principles
 - Develop important abilities such as reasoning, careful observing, and logical analysis(Minstrell, J., 1989)
- “In comparison to traditional instruction, under expert modeling instruction, high school students average 1.5 standard deviations higher on standard instruments for assessing conceptual understanding of physics.”
(Legleiter, 2005, p. 79)
- The process of generating and testing hypotheses is a cognitive skill that has the potential of raising student achievement as much as 30 percentiles for a student functioning at the 50th percentile level.
Classroom Instruction That Works (Marzano, 2001)
- The new [research-based] guidelines [on how students learn] emphasize helping students develop:
 - Familiarity with a discipline's concepts, theories, and models;
 - An understanding of how knowledge is generated and justified; and
 - An ability to use these understanding to engage in a new inquiry*How Students Learn: Science* (Bransford & Donovan, 2005)
- Research on *memory and retention* from countless studies indicate that although lecture continues to be the most widely used method in the classroom, students retain the most by:
 - Teaching others, practicing by doing, and discussing in groups
 - Immediate, active use of learning
 - Shorter, diverse lessons with different means of instruction(Sousa, 1995)

Review Questions

With those at your table, discuss and answer the following questions to review the learning that occurred during the first session.

1. How does inquiry, as an instructional strategy, support student understanding of science concepts?
2. What are the implications for teachers of the research on *How People Learn*?
3. How does use of an Experimental Design Diagram support the development of student understanding of science concepts?
4. Formative assessments provide feedback from the student to the teacher and from the teacher to the student. Explain how whiteboard discussions can be used formatively to determine what students understand.
5. What are the characteristics of a learner-centered environment and why is it important for development of student understanding?

Each table should prepare a whiteboard of their response to one of the questions and be prepared to present your group's response to the whole group for discussion. (The facilitator will assign one question to each table group.)

Notes:



Evaluate a Unit of Study

Now, evaluate your own unit of study with the following two tools to determine how well you are currently developing student understanding.

Self-evaluation on Indicators of Quality: Understanding

Unit of Study										
Self Assessment										
Rate the following statements using this scale:					<table border="1" style="display: inline-table; border-collapse: collapse; text-align: center;"> <tr> <td style="width: 20px;">1</td> <td style="width: 20px;">2</td> <td style="width: 20px;">3</td> <td style="width: 20px;">4</td> <td style="width: 20px;">5</td> </tr> </table>	1	2	3	4	5
1	2	3	4	5						
To what degree do the lessons in my unit of study _____ include opportunity for quality questioning _____ provide adequate time and structure for wrap-up _____ provide strategies and activities that reflect attention to students' preparedness and prior experience _____ provide opportunity for students to question, reflect, and challenge ideas _____ provide adequate time and structure for "sense-making" _____ portray science as a dynamic body of knowledge continually enriched by conjecture, investigation analysis, and/or proof/justification _____ provide opportunities for interactions among students that reflect collegial working relationships _____ include instructional strategies that are consistent with investigative science										

Summarize your goals for this two-day session. Which goal would you like to focus on when you return to the classroom, given your interests and your students' needs?

Unit Evaluation Form

Unit: _____ Name: _____

Please estimate to what degree your current unit meets the criteria for high quality.

	Current unit ...					Revised unit...				
	low				high	low				high
a. Inquiry strategies are evident that engage the students in the concepts and develop student understanding.	1	2	3	4	5	1	2	3	4	5
b. Formative assessments are part of the unit plan and are used to measure student progress toward understanding.	1	2	3	4	5	1	2	3	4	5
c. Instructional activities build on the prior knowledge of students and address preconceptions.	1	2	3	4	5	1	2	3	4	5
d. Students are provided with daily opportunities for wrap-up and support sense-making of the science concepts.	1	2	3	4	5	1	2	3	4	5
e. Inquiry questioning strategies are planned for as part of collaborative science discourse.	1	2	3	4	5	1	2	3	4	5
f. Students are provided with multiple opportunities to learn and understand the big ideas and key concepts.	1	2	3	4	5	1	2	3	4	5
g. Students are provided with opportunities to continually refine their understanding through practice, review and revision.	1	2	3	4	5	1	2	3	4	5

Summarize what you discovered and compare these findings to your personal goals. Revise your personal goals as needed.

Participant's Manual

Designing Effective Science Lessons

CREATING A LEARNING
ENVIRONMENT

By Jan Tuomi & Anne Tweed
with Heather Hein



Designing Effective Science Lessons

Creating a Learning Environment

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INTRODUCTION

Notes:

Welcome to *Designing Effective Science Lessons: Creating a Learning Environment*. This fourth and final *DESL* session focuses on creating an environment in your classroom that promotes learning. The learning environment includes relationships among students and between the teacher and the students, the physical space of the classroom, and the expectations and norms for learning and behavior. In session 2, we learned about identifying the right content and in session 3, we learned about developing student understanding. A learning environment is the third piece of the puzzle. The authors of this manual, after reviewing the research on effective science lessons, came to the conclusion that focusing on these three essential elements will increase overall lesson quality. This is the C-U-E framework at the heart of *Designing Effective Science Lessons*: rigorous *content*, instruction that develops *understanding*, and an *environment* centered on learning.

In the first session, Building the Framework, you were introduced to the first of six strategies for creating a learning environment. This session will review the first session and cover the remaining five strategies. The following table provides an overview of all of the strategies. Remember, the strategies help you focus on the question, “What’s really important?” Ultimately, what matters is student learning, and the substructure of student learning is the classroom environment.

Creating a learning ENVIRONMENT	
Show through your actions that you believe all students have the ability to learn. <i>Begun in Session 1</i>	What’s really important?
Teach students to think scientifically.	
Develop positive student attitudes and motivation to learn science.	
Give timely and criterion-referenced feedback.	
Keep students focused on learning by reinforcing progress and effort.	
Involve students in assessing their own progress.	

As a result of this session, you will

- Understand the above strategies for creating a learning environment and be able to apply them to your own classroom
- Improve the environment in your classroom and the quality of your science lessons, in general

How *DESL* Is Organized

We will begin with a review of the first session. Following the review, we will present new strategies in a format which gives new information and provides opportunities for you to explore, practice, discuss, and personalize the information.

Notes:

Frequently, you will be asked to reflect on current practice, contemplate possible changes, and plan steps to take upon your return to the classroom. The format of each strategy includes three sections:

- **What the Research Says**

After a thorough analysis of the research on science instruction, the authors chose strategies which teachers can implement in their classrooms right away to increase student achievement and learning. This section identifies the research on which the strategies are based and the implications of that research for teachers.

- **Exploring Effective Strategies**

To ensure an understanding deep enough to begin use, each strategy is modeled and then practiced or discussed by participants. These experiences will support the role of each participant as a reflective learner.

- **Planning for Classroom Implementation**

Self assessment and personalized planning tools are provided to help meet a range of teacher needs – including motivation, support and identification of resources – to continue and expand professional development. You are encouraged to apply the strategies learned as you revise a personal unit of study.

REVIEW OF STRATEGY 1: SHOW THROUGH YOUR ACTIONS THAT YOU BELIEVE ALL STUDENTS HAVE THE ABILITY TO LEARN

Review of Research Background

In Building the Framework, we covered the first strategy for creating a learning environment: *Show through your actions that you believe all students have the ability to learn.* To begin this session, let's review the research background that supports this strategy.

- In a **self-fulfilling prophecy**, you form an expectation of a student, which is communicated nonverbally through your behavior. The student then responds to your behavior, behaving in ways that conform to your expectation. The expectation then becomes reality. Self-fulfilling prophecies can be positive or negative. For example, high expectations can lead to high student performance, and low expectations to low performance (Rosenthal, 1998).

Whether we are aware of it or not, we all make split-second judgments about people that are affected by physical characteristics, speech, name, and socioeconomics (Tauber, 1997).

- The **four factor theory** helps explain how teachers convey their expectations to students. The four factors are:

Climate. Climate is communicated nonverbally by smiling and nodding (or frowning and shaking your head), eye contact, and body position. Climate is the tone you set in which all the teacher-student interactions take place.

Feedback. Feedback is both affective (e.g., praise or criticism) and cognitive (e.g., the content, its detail and quality). Feedback is your response to a student action or communication.

Input. Input is the quantity and quality of information you provide the student. Observations of classrooms have shown that teachers actually teach more (provide greater input) to students of whom they have high expectations.

Output. Output is the responsiveness of the student. You encourage greater or lesser responsiveness through verbal and nonverbal cues. (Rosenthal, 1998)

- In session one, we used four statements to sort out our **beliefs about students' abilities to learn**:
 - All kids can learn based on their ability.
 - All kids can learn if they take advantage of the opportunity to learn.
 - All kids can learn if we accept responsibility for ensuring their growth.
 - All kids can learn if we establish high standards of learning that we expect all students to achieve.(Eaker, DuFour & DuFour, 2002, pp. 141-142)

Notes:

Think Back

What do you remember about the *environment* part of the first session? What are some of the teacher beliefs that can interfere with learning?

Provide your reaction to the statement, “Actions **can** change beliefs.”

STRATEGY 2:

TEACH STUDENTS TO THINK SCIENTIFICALLY

What the Research Says

Notes:

This is what the selected research says about thinking scientifically:

- “We teach according to how we understand the nature of what we are teaching and according to how we understand the nature of learning. ... Science is a major area of human mental and practical activity which generates knowledge that can be the basis of important technological applications as well as of intellectual satisfaction. It is an important part of the education of all, not just of scientists, to be aware of the status and nature of scientific knowledge; how it is created and how dependable it is” (Harlan, 1992, p. 2).
- “Simply telling students what scientists have discovered, for example, is not sufficient to support change in their existing preconceptions about important scientific phenomena. Similarly, simply asking students to follow the steps of “the scientific method” is not sufficient to help them develop the knowledge, skills, and attitudes that will enable them to understand what it means to “do science” and participate in a larger scientific community (Donovan & Bransford, 2005, p. 398).
- “In the long run, no scientist, however famous or highly placed, is empowered to decide for other scientists what is true, for none are believed by other scientists to have special access to the truth. There are no pre-established conclusions that scientists must reach on the basis of their investigations (AAAS, 1990, p. 7).
- “There can be no future for the human experiment unless a critical mass of involved people understands that the laws of nature constrain our activities and that our solutions to these problems must be based on knowledge and not blind adherence to fads” (Moore, 1993, p. viii.).

Think About It

Why do we want students to learn to think scientifically?

Will learning to do so improve the quality of the science classroom environment?

Notes:

Exploring Effective Strategies

What Is “Thinking Scientifically”?

1. Work individually to answer the question, “What is thinking scientifically?” Try
 - brainstorming qualities or criteria
 - creating a concept map
 - writing outcomes such as answers to “A student is thinking scientifically when he or she _____.”
2. Working in a small group, first share your individual thoughts.
3. At this point also bring into the development of an “answer” the many expert resources in science and science education that have been publishing, debating, and philosophizing on this topic for decades. To focus on the K-12 science classroom, primary sources should include the *National Science Educations Standards* (especially Inquiry and Nature of Science standards) and the *Benchmarks for Science Literacy* (especially the Habits of Mind), but many more resources are available. Take some time to browse, read, and discuss.
4. Develop a poster or presentation that answers the question. The form is up to you — list, graphic, concept map, chart — but must include a visual element. Be prepared to present its content within a two-minute presentation time.