

**SOLAR ENERGY
EDUCATION & TRAINING**

**BEST
PRACTICES**

Becoming an
Effective Teacher



Interstate Renewable Energy Council, Inc.

U.S. DEPARTMENT OF
ENERGY | Solar Instructor
Training Network
National Administrator

 **SunShot**
U.S. Department of Energy

www.sitnusa.org

Letter from the Program Manager for IREC

National Administrator of the Solar Instructor Training Network

As a boy, I was fascinated with tools while working with my father, and later, as an electrician in the construction industry. The phrase, the right tool for the right job, became readily apparent to me. I appreciated the value of using the right tool to complete a task efficiently, producing a high-quality result. As a former community college professor of 32 years, I look at the Best Practices documents with the same appreciation of the right tool for the right job.

IREC assembled some of the best experts in the country on solar training, education, and workforce development to create this compendium of Best Practices. I am forever indebted to them for their efforts. The documents were thoughtfully designed to give solar instructors the right tools for the job of training a highly-skilled, globally-competitive solar energy workforce for the 21st Century. This suite of Best Practices documents builds on IREC's earlier versions of Best Practices from 2008 and 2010.

As a college professor building my solar program, I had scarce resources and tools to choose from to support my efforts. Separately and collectively, these Best Practices documents enable instructors to easily enhance current solar curriculum, while providing a detailed roadmap for instructors who are considering adding solar to related trades curriculum. These documents have the potential to significantly enhance the quality of solar education and training. How I wish I had something like these Best Practices when I was developing my solar program.

And now, thanks to the SITN, you do. As National Administrator of the SITN, IREC believes these documents will hasten the development of exemplary solar training programs. I am enormously proud to be associated with such an erudite team of solar educational professionals.

IREC will be working closely with the Regional Training Providers (RTPs) of the SITN to further enhance these Best Practices documents. By tapping the strengths of each RTP, the SITN will garner even more resources and best practices to share with solar instructors, creating an even brighter future for solar education and training here in the U.S.

From all of us at the SITN and IREC Team, we are pleased to offer these tools for you in your work.

Joe Sarubbi

PROJECT MANAGER

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Ezra Auerbach

Executive Director, North American Board of Certified Energy Practitioners

Jim Dunlop

Jim Dunlop Solar

Brain Hurd

Hands On Solar, Inc.

Christopher LaForge

Great Northern Solar

Andrea Luecke

Executive Director, The Solar Foundation

Dr. Barbara Martin — Lead Author

Educational Consultant, Former Professor

Doug Payne

Executive Director, SolarTech Consortium

Joe Sarubbi

Project Manager for IREC – National Administrator of the SITN

Dr. Jerry Ventre

Engineering and Education Consultant, Former Director, Photovoltaics and Distributed Generation Division, FSEC

Jane Weissman

Executive Director, Interstate Renewable Energy Council

Dr. Sarah White

Senior Associate, Center on Wisconsin Strategy

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About IREC

The Interstate Renewable Energy Council, Inc. supports market-oriented services targeted at education, coordination, procurement, the adoption and implementation of uniform guidelines and standards, workforce development, and consumer protection. IREC's mission is to accelerate the sustainable utilization of renewable energy and energy efficient sources and technologies. IREC is a nonprofit organization formed in 1982.

About the SITN

Launched in 2009, the U.S. Department of Energy established the Solar Instructor Training Network, composed of nine Regional Training Providers (RTPs) to help fulfill a critical need for high-quality, local, and accessible training in solar system design, installation, sales, and inspection through train-the-trainer programs. The nine RTPs are well-established solar training institutions that offer expert trainers and first-class training facilities across the U.S. The institutions and organizations are listed by region:

Region 1: Kennebec Valley Community College and Hudson Valley Community College

Region 2: Pennsylvania State University

Region 3: The Solar Center at North Carolina State University.

Region 4: Florida Solar Energy Center at University of Central Florida

Region 5: Midwest Renewable Energy Association

Region 6: Houston Community College-Northeast and Ontility

Region 7: Salt Lake Community College, Solar Energy International and Utah Solar Energy Association

Region 8: California Community Colleges Board of Governors, California Energy Commission, California Centers for Sustainable Energy, the Labor Management Cooperation Committee

About DOE SunShot Initiative

The U.S. Department of Energy SunShot Initiative is a collaborative national initiative to make solar energy cost competitive with other forms of energy by the end of the decade. Reducing the installed cost of solar energy systems by about 75% will drive widespread, large-scale adoption of this renewable energy technology and restore U.S. leadership in the global clean energy race.

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Introduction

This paper focuses on two primary components of instructional systems design (ISD): the development phase and the implementation phase. These phases address teaching and learning strategies that promote effective instruction. When you design instruction using the ISD process, it is important to know a little about learning theory. If you want to be a good teacher, you have to know how students learn. Here we examine the information processing theory of learning and how it impacts lesson design using an eight-step lesson design plan. We also briefly discuss some adult-learning principles that you can incorporate into teaching and learning strategies. In addition, we provide a few tips for designing and using PowerPoint presentations effectively.

Systematic Program Planning, Instructional Systems Design, and the ADDIE Model

A **systematic program plan** refers to the documented process for creating or revising educational programs, workshops, or courses. **Instructional systems design** (ISD) is one example of a systematic program planning process. It is defined as the systematic design, development, implementation, and evaluation of instructional materials, lessons, courses, or curricula to improve student learning and teaching efficiency.

An ISD model based on **analysis**, **design**, **development**, **implementation**, and **evaluation** (ADDIE) has been used successfully to design and develop instruction in the renewable energy field. To learn more about instructional systems design and ADDIE models, go to the Solar Energy Education and Training Best Practices document on [*Developing a Quality Course*](#).

Figure 1 shows the progression of systematic planning from a generic concept to a specific instructional design model.

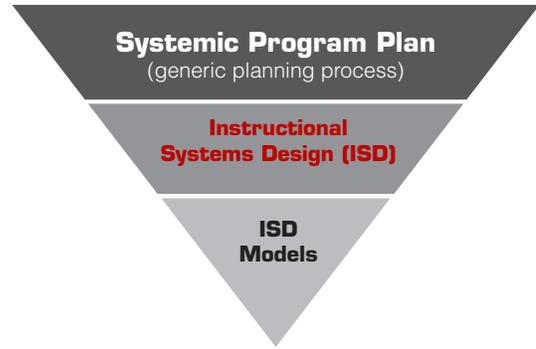


FIGURE 1: Progression from a Generic Concept to a Specific Instructional Design Model

All ISD models are holistic, rather than linear, and have interconnected and interdependent parts that must work together to be successful. One depiction of an ADDIE model is shown in Figure 2 below.

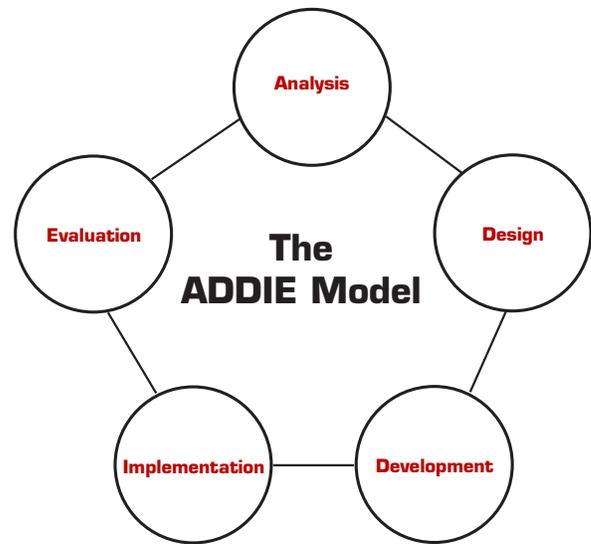


FIGURE 2: Five Phases of the ADDIE Instructional Design Model

The five phases of the ADDIE model are defined as follows:

Analysis – determining whether training is needed and who your students are

Design – determining the outcomes of a training or education program by writing learning objectives and constructing criterion-referenced tests

Development – planning and producing the learning activities and strategies that will be used during a course

Implementation – presenting the course to students using the media and strategies designed during the development process

Evaluation – determining whether or not the course was successful as presented

Information Processing (I-P) Learning Theory

If teaching were the same as telling, we would all be so smart we could hardly stand ourselves!!

Information processing (I-P) theory is a well documented theory about how people learn. Understanding a little about the theory can help you improve your teaching strategies.

If you want to be a good teacher, you have to know how students learn!

I-P theory uses the human brain as a model for learning. Figure 3 shows a representative information processing model. I-P theory postulates that there are three memory systems: sensory memory, short term (or working) mem-

ory, and long-term memory. The human mind takes in information from the environment (it attends or focuses), performs operations to change the form and content of the information (it organizes the information in some logical way), and stores the information in the long-term memory so that it can later be retrieved when it is needed.

The short-term, or working, memory has a very limited capacity. Information is held there for just a few seconds. Because of this, and the limited capacity of the working memory, information must be **chunked** into groups for it to be meaningful. Since only a few chunks of information can be held in the short-term memory at any one time, ideas must be organized into **meaningful** units.

Chunking Information for Learning

Your Social Security number can be more easily remembered by chunking it into three parts.

SSN: xxx-xxx-xxxx

The same is true of your phone number. That's why we used to be able to remember so many numbers before cell phone address books did it for us.

In summary, processing information involves gathering information by **attending** to it and representing the information in the short-term memory — which is called **organizing** and **encoding**. Holding the information or transferring

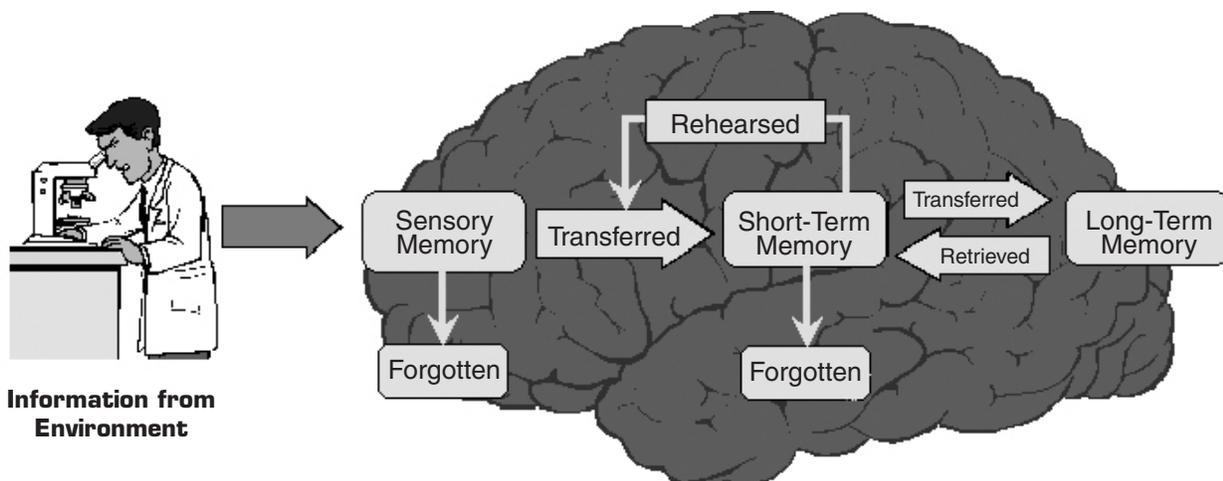


FIGURE 3:
The I-P Theory Model for Learning

it to the long-term memory lets you **store** it until you need to **retrieve** it. Understanding these processes and memory structures can help instructors prepare and present instructional materials more effectively.

For more about using the information processing approach in the classroom, go to: <http://www.edpsycinter-active.org/topics/cognition/infoproc.html> and <http://www.istheory.yorku.ca/informationprocessingtheory.htm>.

Effective Adult Learning Practices

Knowing a little about how adults learn can also make you a more effective teacher. Adults learn in the same way children do but have special needs and requirements as students.

Malcolm Knowles, a pioneer in adult learning, based his work on the concept of **andragogy** (the art and science of how adults learn). He noted that adults:

- Need to know **why** they are learning something
- Prefer **choice** and **self-direction**

- Learn through **doing**
- Are **problem solvers**
- Learn best when the subject is of **immediate use**
- Prefer **social interaction**
- Want to **use their life experiences** in the classroom
- Want **to integrate new ideas** with existing knowledge

To read more about principles of adult learning and to find specific adult-learning techniques and strategies, go to:

- <http://www2.honolulu.hawaii.edu/facdev/guidebk/teachtip/teachtip.htm#learn>
- <http://www.teachermentors.com/adultLrng.php>
- http://www.visionrealization.com/Resources/Organizational/Adult_Learning_Theory.pdf

See also: *Good Teaching Matters: Five Teaching Practices to Improve the Quality of a Training Course*. (This short article discusses a “learner-centered” culture in education and training and describes how instruction can be designed to capitalize on what we know about learning and adults). <http://irecusa.org/wp-content/uploads/2010/12/IREC-Teaching-Matters-12-15-10-Web.pdf>

Key Tips for Teaching Adults:

- Plan some activities where students can direct their own learning
- Use active participation and groups for social interaction
- Use a variety of teaching and learning methods, including hands-on learning
- Make the learning relevant to what students will be doing when they leave the classroom
- Spend less time lecturing and let students work on solving problems
- Provide a supportive learning environment with multiple resources, breaks, and opportunities to ask questions and correct mistakes

Eight Steps in Learning Design

Given what we know about the way adults learn, how should we develop and deliver instruction? Instructional designers often use an eight-step model to design individual units and lessons. This model takes into account information processing theory and adapts it for adult students.

For Example, this lesson design model emphasizes how to help students attend, organize, encode, store,

and retrieve information. Students become adept at moving information from their long-term memories when they need it and storing it back in a place where they can retrieve it for later use. Many different adult-learning techniques and practices can be used to facilitate this process.

The eight steps are presented on the left side of the table below and the IP learning-theory and adult practices are presented on the right side.

Lesson Design	
Step	Process and Purpose
1. Introduce the topic	Attend – Help the student focus on what is important using the sensory and short term memories
2. Present the objective	Attend and organize – Remind students what they already know (the prerequisites), tell them what they have to learn, and explain why they have to learn the material
3. Present the material 4. Show correct performance	Organize and encode – Integrate new information with existing knowledge and use social interaction
5. Provide practice 6. Give feedback	Organize, encode, and store – Use active learning techniques such as problem-solving, social interaction, and case studies that let students find their own strategies for learning and remembering
7. Assess student performance	Retrieve – Use situation-based tests and real-life examples to prompt students to pull knowledge and information from their long-term memory
8. Provide reviews and summaries	Store and Retrieve – Move information back and forth between the short- and long-term memory for more effective storage and retrieval

Here are some additional ideas for three of the lesson design steps presented on page 8:

1. Introduce the topic

Attend – Help the student focus on what is important using the sensory and short term memories

Use an Advance Organizer

When you introduce a topic to students, you want to make sure that they focus on what is most important. An advance organizer is a well-organized and simple framework that shows what will be presented in the lesson. A birds-eye view of the topic, it shows how the components that will be learned relate to each other. It can also show the relationship of prerequisites to the overall topic and what tasks lie ahead for the students. From an information-processing perspective, an advance organizer helps the student attend, organize, and encode information in a meaningful way **at the beginning of a lesson**. It can also chunk the information into meaningful bits.

Below in Figure 4, is an example of an advance organizer for a PV System. It shows each component of a PV system and how the components relate to each other. When shown this at the beginning of an instructional unit or lesson, the students have an advanced understanding of where

the instruction is going and how the various pieces fit together.

Once an advance organizer is presented at the beginning of a lesson or unit, it can be used in a variety of ways throughout the instruction. Using the example below, as each new component of the PV system is taught to students, the advance organizer can be presented again to show how the newly introduced component fits into the overall system. This advance organizer can also be used at the end of a unit or lesson as a summary or review at the beginning of each session to bring information back into the students' working memory.

Advance organizers can be graphics, illustrations, pictures, case studies, examples, or film clips. Anything will work as long as it provides a comprehensive picture of what students need to learn in a simplified manner and shows relationships among the components. It sets the stage by chunking large bits of information into manageable pieces.

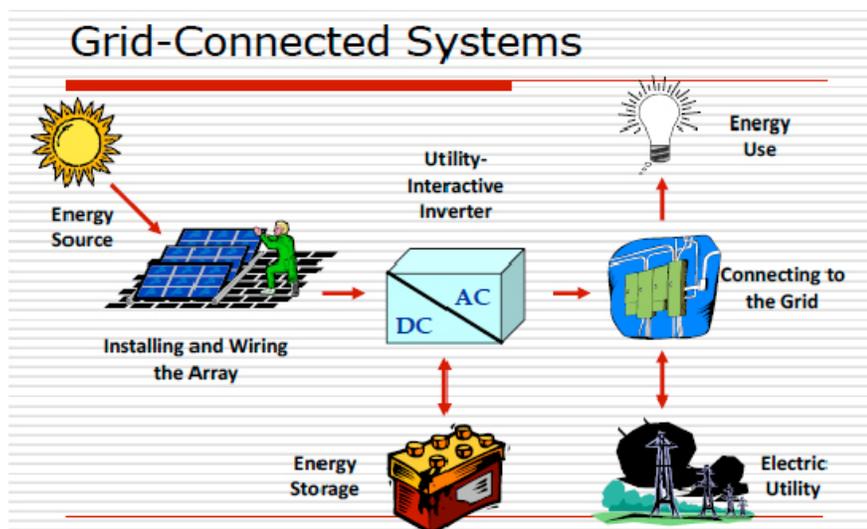


FIGURE 4: Example of Advance Organizer

- 5. Provide practice
- 6. Give feedback

Organize, encode, and store – Use active learning techniques such as problem-solving, social interaction, case studies that let students find their own strategies

Provide Practice and Feedback

Practice and feedback are key to effective teaching and instruction. There are several learning-theory and adult-learning principles that directly state that students must be **cognitively active** when they are learning. Students typically start with a relatively simple idea about what they are learning when they enter a classroom. But they must leave the class with a more complex and integrated understanding of the content.

Almost all educators believe that providing quality practice and immediate feedback is critical to student learning.

Ambrose, et al. (2010) say that instruction occurs when teachers take students from where they are when they enter a course (i.e., their prior knowledge, life experiences, values, attitudes and beliefs, and goals) and influence how the students interpret, use, organize, apply, and retrieve new information. Teachers also must influence how students adjust to new situations. **Goal-directed practice coupled with targeted feedback enhances the quality of learning. More practice generally increases the quality of student performance.**

Here are three key principles about practice and feedback:

1. **Students must be actively involved with the content to learn.** Students who interact with content learn more information more quickly than those who are subjected to the “sit-and-get” method. Students must get their brains

working by trying things out, seeing what works and what doesn't, “playing” with the ideas, engaging in problem solving and making decisions. Notice, students have to be cognitively active, not necessarily physically active.

2. **It is more effective to teach by example than by explanation.** In the sit-and-get mode of instruction, teachers try again and again to explain ideas and concepts. However, when instructors use examples, students engage cognitively and try to make sense of what they are learning. The examples that teachers use should reflect real life and be moderately difficult. Instructors should ask students to do some problem solving, troubleshooting, application, analysis, or decision making.

3. **Use both confirming and corrective feedback.** When students are engaged in practice, they tend to learn more if they are given feedback. **Confirming feedback** acknowledges that students gave the right answer or solution or are on the right track in what they are learning. **Corrective feedback** is given when students are on the wrong track or have the wrong answers. **Corrective feedback** helps students reorganize and redirect their knowledge and thinking.

Remember the old adage: **Practice makes perfect!** If you want your students to correctly perform on the job, give them multiple opportunities to practice in the classroom and to learn from their mistakes.

To learn more about providing practice and feedback, go to [*Good Teaching Matters: Section 4, Include Practice and Feedback in the Training.*](#)

Make lectures more meaningful by actively engaging students. Use questions and answers, puzzling situations, case studies, and problem solving activities.

7. Assess student performance

Retrieve – Use situation-based test and real-life examples to pull knowledge and information from the long-term memory

Assess learner performance

In the Best Practices document on *Developing a Quality Course*, we address **critterion-referenced testing** which means writing assessment instruments that clearly evaluate the stated learning objectives. Given what we know about I-P learning theory and the adult-learning principles, students should be tested with problem-based, situation-based, and scenario-based testing.

A scenario-based test for PV would ask students to solve real-world PV problems based on a case study or real-life situation. In each case, students are solving problems on paper. The students are operating (1) at the higher levels of Bloom's taxonomy (analysis, synthesis, and evaluation), (2) are presented with a conflict, and (3) must face a problem that is as complex as what they will find on the job. Some examples include:

- Describe how you would install a system on a site with significant shading.
- Decide where to place a PV array when the roof size has inadequate square footage.
- Troubleshoot a non-working system from a set of customer complaints.

Students would be given a case study and asked to solve a problem similar to one they might encounter on the job. These kinds of tests facilitate the **transfer** of what they have learned in the classroom to the world of work.

These methods are used because they match the needs of adult students in the following ways:

- Adult students need information and knowledge that has immediate use
- Situation-based tests require adults to solve problems
- Situation-based tests help students as they transfer learning from their long-term memory to real-life situations
- Situation-based tests present conflict or puzzlement — complexity similar to what students might find in the real world
- Tests are typically anchored in a larger task or problem

What about On-line Instruction?

There is a movement in American education and training to put as many courses and workshops online as possible. It is beyond the scope of this paper to examine online, face-to-face, and hybrid delivery (partly in the classroom and partly online) in any depth. Still, we do want to make a couple of remarks here.

First, regardless of which delivery method is chosen, **all instruction must use systematic program planning.**

Using the ADDIE model, for example, it is important to:

- Conduct a needs analysis to determine what has to be learned
- Design and specify learning objectives
- Use criterion-referenced testing and assessment
- Develop learning activities and strategies that help students master the content
- Conduct a program evaluation

Second, **some courses do not lend themselves to on-line training.** Those that have considerable psychomotor

skill learning or field work are not good candidates. Nor are courses that require hands-on assessment procedures. Other poor candidates include courses where testing and assessment procedures cannot be secured and proctored, or where student confidentiality may be at risk.

Third, ***careful consideration needs to be taken with regard to instructional equipment that requires a lot of bandwidth*** such as computers and instructional games. Students should have access to technical experts when they are taking online and hybrid courses.

Fourth, ***students need practice and feedback for learning to be optimal***. When planning online instruction, plans must also be made to provide feedback and remediation to students who need it. This must be done in a timely and organized manner. Students may need feedback before proceeding to the next lesson or unit; provisions must be made in the design.

Even with these considerations, any delivery option is possible as long as the course is well developed using systematic program planning. Some experts believe that hybrid or blended delivery offers the best of both worlds. The following web sites provide additional information about hybrid and blended learning systems: <http://www.educause.edu/Resources/Browse/HybridorBlendedLearning/33312> and <http://www4.uwm.edu/lrc/hybrid/>

Making and Using Effective PowerPoint Presentations

There are many good resources available about how to design and use PowerPoint (PP) presentations. Rather than repeat what is easily found in other places, we would like to discuss a few ideas about PP presentations as they relate to information processing theory and principles of adult learning.

1. **Use progressive disclosure.** Progressive disclosure means presenting small amounts of information rather than presenting a whole slide at once. It allows the instructor to chunk information in manageable bits so that

For on-line delivery of instruction, ask yourself if you can do the following:

- Provide hands-on learning experiences and assessments for courses that require physical skills
- Give feedback to students after practice exercises and tests
- Have instructional conferences as needed for remediation and to solve student problems
- Have technical support for students who experience computer or equipment problems
- Protect student confidentiality regarding grades and personal information
- Ensure that cheating or unauthorized assistance does not occur
- Have proctored exam or testing sites

students can learn it more easily. From the perspective of I-P theory, this allows the instructor to focus attention on what is critical. For example, on a slide with a list of bullet points, the presenter who shows one bullet at a time is using progressive disclosure. Each bullet point is a chunk of information that can be discussed on its own.

2. **Keep it simple.** Avoid cluttering PP slides so that it is easier for students to encode the information.

3. **Communicate without words.** Use graphics, photographs, and illustrations whenever possible to encode the information in new ways. But avoid using what software designers call “dancing baloney.” Research shows that too many bells and whistles can detract from learning.

4. **Use advance organizers and examples.** Rather than presenting text-laden PP slides, use examples, graphics, and real-life scenarios to make your points. Variety helps students organize and encode information for storage into long-term memory.

5. **Ask the students to do something with the information presented on some slides.** Use PP slides to present problems that have to be solved or to ask students to make decisions. This provides students with practice and requires them to apply what they are learning.

6. **Paraphrase the information on the slide, do not read it.** This is called multi-modal communication. It uses complementary messages and dual sensory channels and gives students multiple ways of encoding the same information.

PowerPoint has become the modern day chalkboard. Like the chalkboard it can be used effectively or ineffectively. From a learning perspective, a PP presentation always works best if you can have the students mentally engaged.

To learn more about designing and using PowerPoint, go to the following web sites:

- http://www.cob.sjsu.edu/splane_m/presentationtips.htm
- <http://www.bates.edu/ils/2011/how-do-i/software/powerpoint-presentation-tips/>
- *Good Teaching Matters: Section 5 Create Simple PowerPoint Presentations*

Summary

In this paper, we have addressed the process of learning using information-processing theory and described some key principles of adult learning. We have also applied that information to the development and implementation of a course or lesson. Some of the keys points to remember are:

- The job of the instructor is to help students attend to important information and then organize and encode it so that it can be stored in the long-term memory and retrieved when it is needed. This includes retrieving what students already know (prerequisites) and combining it with what is to be learned.

- Adults learn best when they are active, engaged in problem solving, working with others, and bringing their experiences to bear on the learning.
- Advance organizers, practice and feedback, and situation-based testing can all be used successfully to promote learning with adults.
- Online, face-to-face, and hybrid delivery are all options when presenting instruction. Regardless of the delivery methodology, all courses must use a systematic planning process when you are designing them.
- Develop your PP presentation with an eye toward adult students and I-P learning theory. Use slides that promote student curiosity, require students to solve problems, and provide simulated, real-life situations.

Sources

This document is part of the Solar Energy Education and Training Best Practices document series. All Best Practices documents can be accessed online at <http://sitnusa.org/trainer-resources/best-practices>. Other resources available online are referenced throughout this document with web-addresses and hyperlinks. Text-only resources are listed below.

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K., 2010. How learning works: Seven Research-Based Principles for Smart Teaching. San Francisco: Jossey-Bass.