Instructor-led Technician Training Guidelines 2003

Updated and released July 30, 2003

The Technician Performance Improvement Council is cosponsored by International SEMATECH and SEMI (Semiconductor Equipment and Materials International).

Instructor-led Technician Training Guidelines 2003

TECHNICIAN PERFORMANCE IMPROVEMENT COUNCIL

July 30, 2003

This document is an update and revision of International SEMATECH's *Guidelines for Semiconductor Manufacturing Equipment Reference Manuals, Technician Training Programs, and Training Evaluation* (Technology Transfer #93031567B-XFR), published May 29, 1998, and contains new information about instructor-led training and instructional design techniques not found in the 1998 publication. This document includes the following topics: Instructional System Design Overview, Instructional Strategies, Instructor Guide Formats, revised Evaluation Methods section (including test writing techniques and legal issues), Instructor Certification, Planning Forms for Training Projects, Career Ladder for Equipment Trainers, Glossary of Training Terms, a Reference List, and a refined section on skills related to equipment training.

This document reflects work performed by the Training Guidelines Update Task Force of the Technician Performance Improvement Council.

TPIC Training Guidelines Task Force members include:

Judy Aguilar, Canon USA

Lance Bachmann, Lam Research Corp.

Stephanie Campolito, Cymer, Inc.

Carl Gonzales, SEMI

Michael Kellenberger, Semitool, Inc.

James Keller, KLA-Tencor

Knox Robinson, Novellus

Norrell Rose, Intel

Julian Serda, AMD

Bob Simington, Intel

Angel Soto, Semitool

The Technician Performance Improvement Council is cosponsored by International SEMATECH and SEMI (Semiconductor Equipment and Materials International).

Table of Contents

List of Figures

List of Tables

1 EXECUTIVE SUMMARY

This document is an update and revision of the International SEMATECH *Guidelines For Semiconductor Manufacturing Equipment Reference Manuals, Technician Training Programs, and Training Evaluation* (Technology Transfer #93031567B-XFR). These guidelines furnish basic information and practices for developing instructor-led technical training programs for semiconductor industry personnel.

Topics in this document include the following:

- Instructional System Design Overview
- A refined section on skills related to equipment training
- Instructional Strategies
- Instructor Guide Formats
- Revised Evaluation Methods section, including test writing techniques and legal issues
- Instructor Certification
- Planning Forms for Training Projects
- Career Ladder for Equipment Trainers
- Glossary of Training Terms
- Reference List

The goal of training developers is to create technically reliable and instructionally sound training programs. Technical reliability is a necessity in semiconductor industry training due to the complexity of the equipment. Reliability is basically a function of the detail and accuracy incorporated into the training program content during development.

Training programs are considered instructionally sound if learners master the intended objectives as completely and efficiently as possible. Instructional soundness and technical reliability are ensured when training programs are developed using a proven, systematic process such as Instructional System Design (ISD).

1.1 Target Audience

This document is intended to serve the needs of the following training audiences:

- The experienced training developer/trainer who needs to implement and maintain high quality instructor-led training. The experienced developer will find validation of ISD methods, with specific recommendations for their implementation in the semiconductor manufacturing industry.
- The subject matter expert, with limited training experience, who is required to provide instructor-led training. This user will find clear explanations of how to develop successful instructor-led training results that are repeatable, accountable, and measurable.
- The training supplier who needs to meet the instructor-led training expectations of a semiconductor customer. This supplier will find specific recommendations and tools for meeting the instructor-led training standards of the semiconductor industry.

2 INSTRUCTIONAL SYSTEMS DESIGN OVERVIEW

Instructional Systems Design is a development process consisting of a series of interacting steps or phases. ISD is a systematic approach to training program development that involves the planning, design, creation, implementation, and evaluation of training methods and materials. A systematic process of instructional design is a problem-solving process used to identify instructional problems or needs and to design corresponding solutions. These solutions are based on teaching-learning activities relevant to the identified objectives and desired learning outcomes. This approach can be characterized as a repeating input-output-feedback-revision cycle of activities.

The ISD process has been adapted and used by a variety of industrial, educational, military, and commercial organizations since its original definition by the military in 1976. Consequently, numerous instructional design models have evolved. All models basically adhere to a systematic approach, but the process steps used vary widely. Some ISD models include as many as 14 steps, while others have as few as five.

For consistency, the seven-step ISD model specified in the *International SEMATECH Performance-Based Equipment Training (PBET) Participant Guide* (Technology Transfer #95102995A-TRG) is used as the basis for the information and technical training development practices discussed in this document. (The PBET Participant Guide is available also at www.tpic.org.) For reference, the prescribed sequencing of the seven basic instructional design steps in the PBET model and their key activities are provided in Figure 1. Detailed coverage of these steps and their related activities can be found in the *PBET Participant Guide* mentioned above.

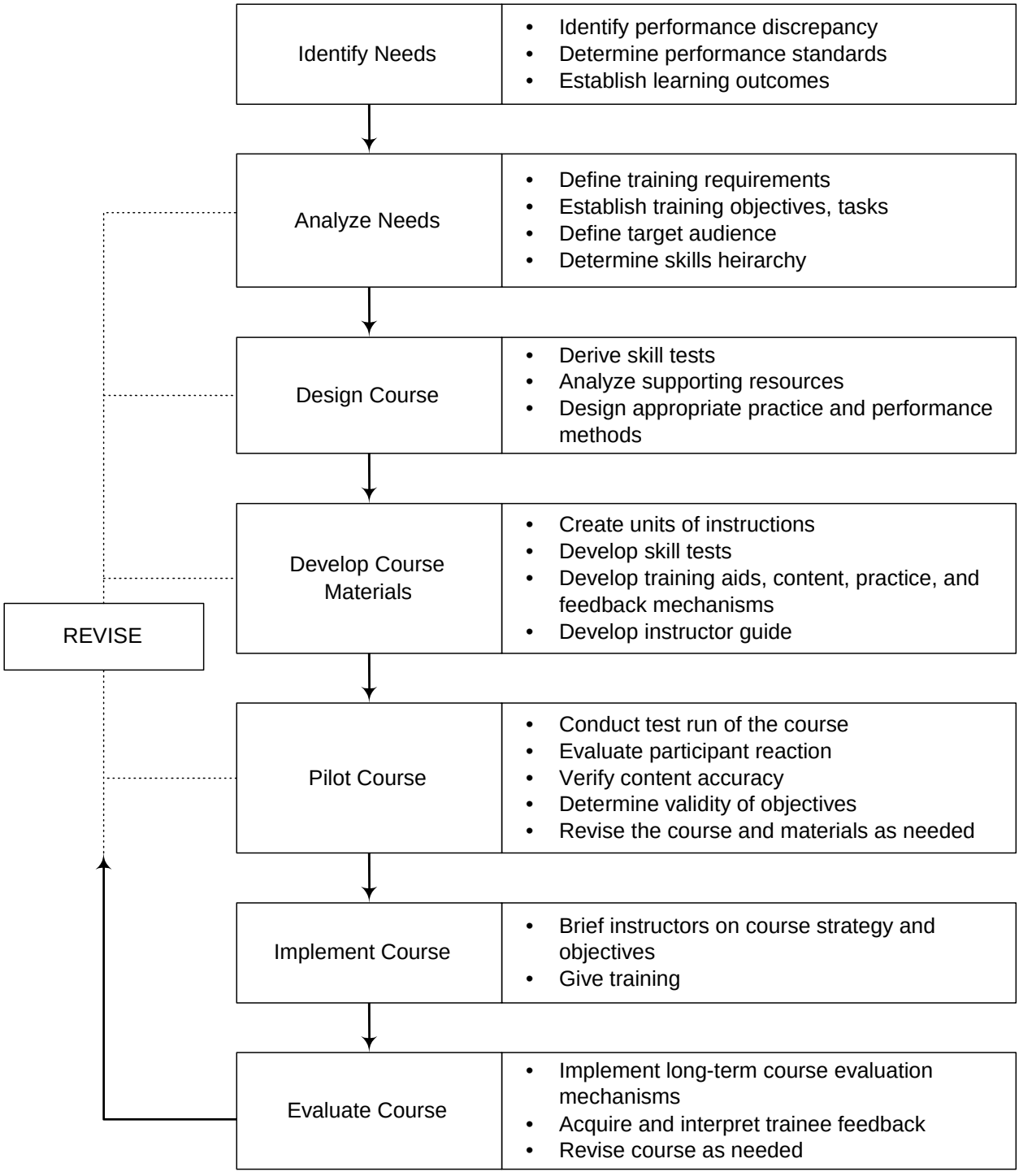


Figure 1 PBET ISD Model

2.1 Benefits of Instructional Systems Design

Given this brief description of an ISD model, what are the benefits of using a systematic approach to training program development? There are several reasons why systematic ISD is effective, including the following:

- Using a systematic ISD approach means using a proven, repeatable process. The reusability of the ISD process steps promotes efficiency and consistency across individual training courses when training for higher-level competencies or periodic content modifications are required. Process results can be readily evaluated and subsequent training program design adjusted to accommodate the necessary learning objectives.
- The close relationship and interdependency between steps also promotes the effectiveness of the ISD process. From the onset of program development, the emphasis of the training is on what the trainee is to know and be able to do. Clearly defined performance objectives will ultimately prescribe the most appropriate instructional strategies and materials.

2.2 Front-End Analysis

The first step in the ISD process begins with identifying one or more performance problems. This problem identification process is called *needs analysis*. A training need is expressed as the gap between "*what is*" and "*what should be*" the performance level in a given situation. Once a need is identified and training is determined to be the solution, instructional objectives (goals) can be established.

The next step in the ISD process is to conduct a *task analysis* of the instructional objectives and performance need(s). This step gathers information to answer the questions, "What type of learning is required for the job to be performed?" "What are the necessary tools and materials, and the subordinate skills associated with tasks?" and "What are the characteristics and profiles of the intended audience?"

This step is essential, as all subsequent design and development activities are dependent on the information obtained. The PBET course covers the task analysis process.

A key result of the task analysis is determining trainee *prerequisites*. These are of particular importance to semiconductor equipment manufacturer training. In order for trainees to successfully achieve competence in the wide range of training programs offered, meeting course prerequisites for each program offering is critical. Satisfying prerequisites ensures that qualified people are selected for specific training and their likelihood of success is enhanced. Section 3.1 of this guideline categorizes common prerequisites and provides examples on how they should be considered in your course offerings.

2.3 Content and Strategies

Course design begins after the task analysis is complete. Design involves developing task skills test items corresponding to the *instructional objectives*, determining the most *relevant practice* and *feedback mechanisms*, and analyzing the existing and most appropriate instructional materials.

The *PBET Participant Guide* covers these design activities in detail and should be referred to for examples. The focus of this document is to provide recommendations on several key training content topics or skills and knowledge deemed most relevant to semiconductor equipment

manufacturer training programs. Semiconductor equipment has a significant range of complexity and requires a multi-disciplined approach to training.

Many suppliers provide training using different course titles and lengths. To ensure that all technical disciplines are covered within supplier program offerings, Section 3 provides guidelines on the kinds of *skills* and *knowledge* that tool users may need in order to become fully competent on the supplier's equipment.

The last activity in the design phase is to determine the most appropriate training methods or *instructional strategies*. Training developers should remember not to enter into a project with a preconceived idea of how the training will be delivered. Based on content, learning categories and levels, practice and feedback mechanisms, the most appropriate *media*, *materials*, and *delivery methods* should be identified and implemented. Section 4 provides guidelines for proven instructional strategies used in the instructor-led technical training field to ensure maximum learning effectiveness.

To this point, the ISD process phases have served to analyze and design the key elements of the PBET lesson plan. With these elements in place, actual *development* of the instructional media, training aids, and instructor materials can begin. Depending on the type of media to be employed, there are numerous resources available to provide development expertise and tools.

2.4 Course Delivery and Evaluations

As the training program evolves, it is important to determine the effectiveness and consistency of the course design and materials with respect to the initial performance objectives. This process, referred to as *formative evaluation*, usually includes reviews by subject matter experts, students, and small groups.

A field trial or *pilot course* is a major step in the PBET ISD model and is detailed in the *PBET Participant Guide*. The results and observations obtained during a formative evaluation (pilot course) are used to correct problems and make *revisions* to the course and instructional materials. It may be necessary to pilot a course several times and revisit previous program development steps before the course is instructionally sound.

Part of conducting a course pilot is to compile instructor-related materials and qualifications. This includes developing the *Instructor Guide* and determining the characteristics of qualified instructors for the course. Guidelines and considerations for developing a practical *Instructor Guide* are presented in Section 5. The effectiveness of instructor materials is directly related to the capabilities of the individuals using them. Instructors not qualified to conduct training can greatly inhibit student learning and confidence. To avoid this situation, Section 7 provides instructor certification guidelines. When closely followed, these guidelines will increase instructor competence and improve training effectiveness.

Course *delivery* follows piloting and revising a course and identifying well qualified instructors. According to the *PBET Participant Guide*, delivery also includes briefing trainers on their responsibilities and integrating the new course into the overall training curriculum. Examine the PBET guide for details, as each of these activities has several associated tasks.

In the semiconductor industry, quality improvement requirements are increasing in the products being built and the services provided. Technical training must also meet customer quality requirements. To ensure the quality of training, a method of feedback should be implemented.

Post delivery *evaluations* are conducted to collect data and verify the effectiveness of instructional materials with target learners. There are several "levels" of evaluation generally applied to training programs. Section 7 provides examples of how evaluations can be implemented, and an update on evaluation methods. With feedback from evaluations, plans can be developed to improve the quality of offered training programs.

The material within these guidelines was developed through semiconductor equipment customer and supplier partnerships and apply to all equipment supplier training organizations. They are written broadly, permitting latitude of applications where advisable, and yet are specific enough to ensure consistency within semiconductor equipment technical training programs.

Use these guidelines for meeting the challenges facing you in the development of effective semiconductor process and maintenance technician instructor-led training programs. Refer to the *PBET Participant Guide* for explanations of the basic ISD steps and detailed training development recommendations. Maintain your awareness of activities being driven by the Technician Performance Improvement Council (www.tpic.org) and call upon that organization for help when you need it or can offer it.

3 EQUIPMENT TOPICS, SKILLS AND KNOWLEDGE

3.1 Prerequisites

3.1.1 Definition

Prerequisites are the knowledge and skills a trainee must have prior to entering a specific training program. Prerequisites are determined by the performance objectives and content of the training program.

3.1.2 Importance

Prerequisites ensure that individuals with adequate background knowledge or skills are selected for each course offering. Meeting a course's prerequisites multiplies the probability that the trainee will successfully complete the course. Therefore, it is recommended that all programs of instruction specify prerequisites, and the prerequisites be used by customers in the selection and screening of potential trainees. Prerequisites should be reviewed and validated periodically.

3.1.3 Types of Prerequisites

Prerequisites categories and their definitions are shown in Table 1.

Table 1 Types of Prerequisites

Category	Definition	Examples
Administrative	Ensure compliance with training rules, regulations, and policies	• Security clearance • Pay grade • Length of service • Employment status
Physical	Trainee's physical capabilities on the job and in the classroom	• Motor coordination • Vision • Hearing
Experience and Skills	Considers trainee's previous background	• Work experience • Military experience • Special skills and abilities
Educational	Trainee's level of formal education and prior specialized training	• Completion of basic process related courses • Completion of other equipment courses • Basic computer skills • Semiconductor oriented safety training • Mechanical knowledge • Electrical knowledge • Training in basic physics and chemistry • Knowledge of mathematics and statistics

3.2 Course Content Category Definitions

This section provides recommendations to training managers, instructors, and course developers regarding categories of topics, in the form of skills and knowledge, that can be included in their equipment training programs.

Each equipment topic in these guidelines is broken down into a list of knowledge and skills required for the topic. Each knowledge or skill represents specific course activities a trainee must do to be qualified or certified in that particular group of skills.

Training course content can be classified into one of seven categories:

1. Process
2. Procedure
3. Structure
4. Concept
5. Principle
6. Fact
7. Classification

Table 2 provides definitions and examples of the seven course content categories.

Table 2 Course Content Category Definitions

Category	Definition	Examples	Non-Examples
Process	A series of events or changes occurring over time, usually with an identifiable result.	*WHAT HAPPENS during the metallization step?* *EXPLAIN HOW a wafer moves through the production line.*	*HOW to operate a defect inspection tool*
Procedure	An ordered sequence of steps performed to obtain a required outcome.	*HOW TO start up the processing tool* *HOW TO maintain a vacuum pump*	*You must wear personal protective equipment when performing this task.*
Structure	A physical or abstract object that can be divided into parts having boundaries.	*A block diagram showing relationships of major subassemblies*	*Native oxide growth on silicon wafers*
Concept	A set of items that share a unique combination of critical characteristics, and can be referred to by a common name or symbol.	*Technical terms such as etch selectivity and profile* *Relationships and ideas such as defect density and die yield*	*Field Effect Transistor*
Principle	Statements telling what should or should not be done or what seems to be true in light of evidence. Common forms include: rules, policy statements, and assumptions.	*Keep work site clean and contamination free.* *The pressure in the chamber is the sum of the individual gas pressures*	*Silicon atoms form covalent bonds.*
Fact	Statements or assertions made without supporting evidence.	*Measurement (12 inches = 1 foot)* *Silicon atoms form covalent bonds*	*A block diagram showing major subassemblies*
Classification	A way to organize a group of items into classes or categories using one or more sorting attributes.	*Hazards can be categorized as chemical, mechanical, etc.* *Wafer processing steps can be classified under layering, patterning, etc.*	*A block diagram showing relationships of major subassemblies*

3.3 Equipment Topics: Skills and Knowledge

A major challenge in designing courses is to logically organize and structure content. Table 3 presents an approach to organizing equipment topics into the knowledge and skills activities that can be taught in the classroom. Each knowledge or skill is then categorized by course content type. Section 3.4 provides a model of recommended course material formats for each category of course content.

3.4 Designing Instructional Materials

Categorizing performance objectives (i.e., course content) provides guidelines for designing the intended instructional results.

Table 3 Equipment Topics and Related Skills and Knowledge

		Course Content Categories						
Topics	Skills and Knowledge	Process	Procedure	Structure	Concept	Principle	Fact	Classification
Equipment or Process Overview	Describe process flow through a wafer fab	X						
	Name each process step						X	
	Describe process parameters for a specific process step and equipment	X	X					
Facilities	Identify and explain all facilities requirements			X			X	
	Trace and explain various facilities throughout the system	X	X					X
	Explain how facilities problems affect tool performance	X				X	X	
Controls and Indicators	Locate major controls and indicators						X	
	State how each control affects machine status	X		X				
	State how eachindicator monitors changes	X						
	Demonstrate use of machine displays		X		X			
Safety Hazards and Precautions	Identify safety hazards and precautions				X		X	X
	Describe safety procedures		X			X		
	Locate safety interlocks						X	
	Explain interlock functions	X		X	X			
	Explain consequences of safety violations					X		
Machine Assemblies and Theory of Operation	Explain the function of each major subsystem components	X		X				
	Explain operational interrelationship of major components and assemblies	X						
System Integration and Control Systems	Locate and identify major components for each control system			X				X
	Monitor major control system signals		X					
	Trace signal pathways through the system	X						
	Demonstrate understanding of SECS control	X	X	X				

Table 3 Equipment Topics and Related Skills and Knowledge (continued)

		Course Content Categories						
Skill Set ID	Performance Objectives	Process	Procedure	Structure	Concept	Principle	Fact	Classification
Software	Identify and explain basic prompts and edit control keys			X				
	Access menus and files		X					
	Explain purpose of major tasks, commands, command options	X						X
	Program the system		X					
	Access and use diagnostics systems		X					
	Demonstration of an understanding and application of SECS interfacing		X					
	Identify and explain software "bugs"							X
	Observe normal operation states	X						
	Perform system initialization		X					
	Perform system shutdown		X					
	Perform system setup		X					
	Perform system failure recovery		X					
System Operation	Process wafers through system		X					
	Identify and explain "operator assists"	X						X
	Perform troubleshooting		X					
	Demonstrate understanding of hardware and software response indicators	X		X				
Machine Assemblies and Theory of Operation	Explain the interaction of all calibration adjustments	X		X				
	Identify and explain use of all required tools and test equipment		X					
	Explain basic strategy of adjustments and calibrations				X	X		
	Explain when adjustments and calibrations should be performed	X				X		
	Explain consequences of not performing calibrations					X	X	
	Demonstrate an understanding of requalification for process after calibration is performed	X	X					
	Perform designated calibrations and adjustments in accordance with specifications		X					
	Demonstrate an understanding of safety issues for PM procedures					X	X	
	Monitor major control system signals					X	X	
	Demonstrate understanding of process contamination control	X	X					

Table 3 Equipment Topics and Related Skills and Knowledge (continued)

		Course Content Categories						
Skill Set ID	Performance Objectives	Process	Procedure	Structure	Concept	Principle	Fact	Classification
Preventive and Corrective Maintenance	Describe the philosophy of preventive maintenance (PM)					X		
	Perform designated PM and corrective maintenance according to specified documentation		X					
	Perform tests to ensure system is production ready after PM or corrective maintenance		X					
	Determine probable cause and corrective action for system problems	X	X					
Diagnostics and System Level Troubleshooting	Access and use diagnostic programs		X					
	Demonstrate an understanding of system diagnostics for wafer, process, or equipment problems and the cause and effect relationships			X				X
	After troubleshooting is complete, review and evaluate problems	X						X
	Demonstrate an understanding and correct usage of documentation on diagnostics and system level troubleshooting	X	X					
	Demonstrate an understanding of schematics and interconnect diagrams	X	X					
	Identify and explain error messages and software "bugs"	X		X				X
	Perform advanced troubleshooting		X					
Machine Processing	Explain the equipment processing sequence	X						
	Demonstrate the equipment processing sequence		X					
	Demonstrate an understanding of upstream and downstream process equipment effects	X						
	Demonstrate an understanding of contamination causes and effects				X		X	X
	Demonstrate understanding of system process control	X	X		X			
	Demonstrate an understanding of statistical process control techniques		X			X	X	

Table 3 Equipment Topics and Related Skills and Knowledge (continued)

		Course Content Categories						
Skill Set ID	Performance Objectives	Process	Procedure	Structure	Concept	Principle	Fact	Classification
System Setup Check-Out and Shutdown	Perform step-by-step power up and power down operations		X					
	Perform machine checkouts		X					
	Perform an emergency power down operation		X					
Documentation	Demonstrate ability to use all technical manuals and drawings		X					
	Explain procedures for obtaining product service and spares support		X					
	Identify and describe available product options	X		X				X

3.4.1 Recommended Training Presentation Formats

Table 4 lists the recommended presentation forms for developing instructional materials for each of the seven categories of course content.

Table 4 Suggestions for Presentation Formats

If content type is a....	*THEN identify....*	*Recommended Formats*
PROCESS	PROCESS CHARACTERISTICS:	WHEN-THEN Table
	Involves conditions and responses	WHEN-IF Chart, Flow Diagram
	Describes a chain of causes and effects within a machine	Cycle Chart Block Diagram
	Involves multiple information types	State Diagram
	Repeats itself	Events and Effects Matrix
	Involves different courses of action	
PROCEDURE	STARTING POINT OR ACTION	Procedure Table
	ACTION STEPS	Decision Table
	DECISION STEPS	Worksheet
	ACTIONS OR STEPS TO REPEAT	Checklist
	OUTCOME SOUGHT	Flow Chart
STRUCTURE	OBJECT(S)	Descriptive Statement or Pictures
	COMPONENT PARTS	Block Diagram
	OBJECT BOUNDARIES	Component Parts Table
		Part-Function Table
CONCEPT	CONCEPT NAME	Definition Statement
	TYPE OF CONCEPT	Examples
	EXAMPLES	List of Applications

If content type is a....	*THEN identify....*	*Recommended Formats*
PRINCIPLE	TYPE OF PRINCIPLE:	Use strong, active voice
	Policy	Provide examples
	Rule	Use non-examples
	Guideline	Explain principles
	Standard	
	Law	
	Assumption	
	Goal/Objective	
FACT	TYPE OF FACT:	Specification Table
	Specification	Specification Listing
	Measurement	Descriptive Statement
	Dates & Events	List of References
	Experimental Results	
CLASSIFICATION	CATEGORY NAMES	List
	CLASSIFICATION TYPE	Classification Table
		Compare and Contrast Table
		Classification Tree

3.5 The Use of Course Maps

Arranging individual performance objectives into a logical sequence helps illustrate how the different skills relate to each other -- which ones are prerequisites and the order in which they can be performed. This concept is further simplified using the course mapping methodology mentioned here, but covered in more detail in the PBET program.

NOTE: Refer to the *International SEMATECH Performance Based Equipment Training Participant Guide* (Technology Transfer #95102995A-TRG) for more details on the how to write performance objectives and develop course maps. The document is available on the Internet at www.tpic.org.

A course map is like a roadmap leading students through the most logical paths in a training course. The course map is a graphical representation of the paths in a course. It shows how the subordinate skills relate to each other and the order in which to perform them.

The structure of the “hierarchy of skills” in the following generic course map for operations training shows how instructional elements are logically arranged. The course map is read from the bottom up. Students start from the lowest skill that matches their own specific learning needs, then work through the remaining modules until the terminal objective is satisfactorily completed.

The advantages of course maps over conventional course outlines include the following:

- It is easy to see how learning modules relate to each other.
- Instructors and students can see at a glance the recommended order in which learning modules should be performed.
- Instructors and students can take alternative paths based on needs, scheduling and availability of resources.
- The course can be easily customized to meet a customer’s needs.

3.5.1 Examples of Course Maps

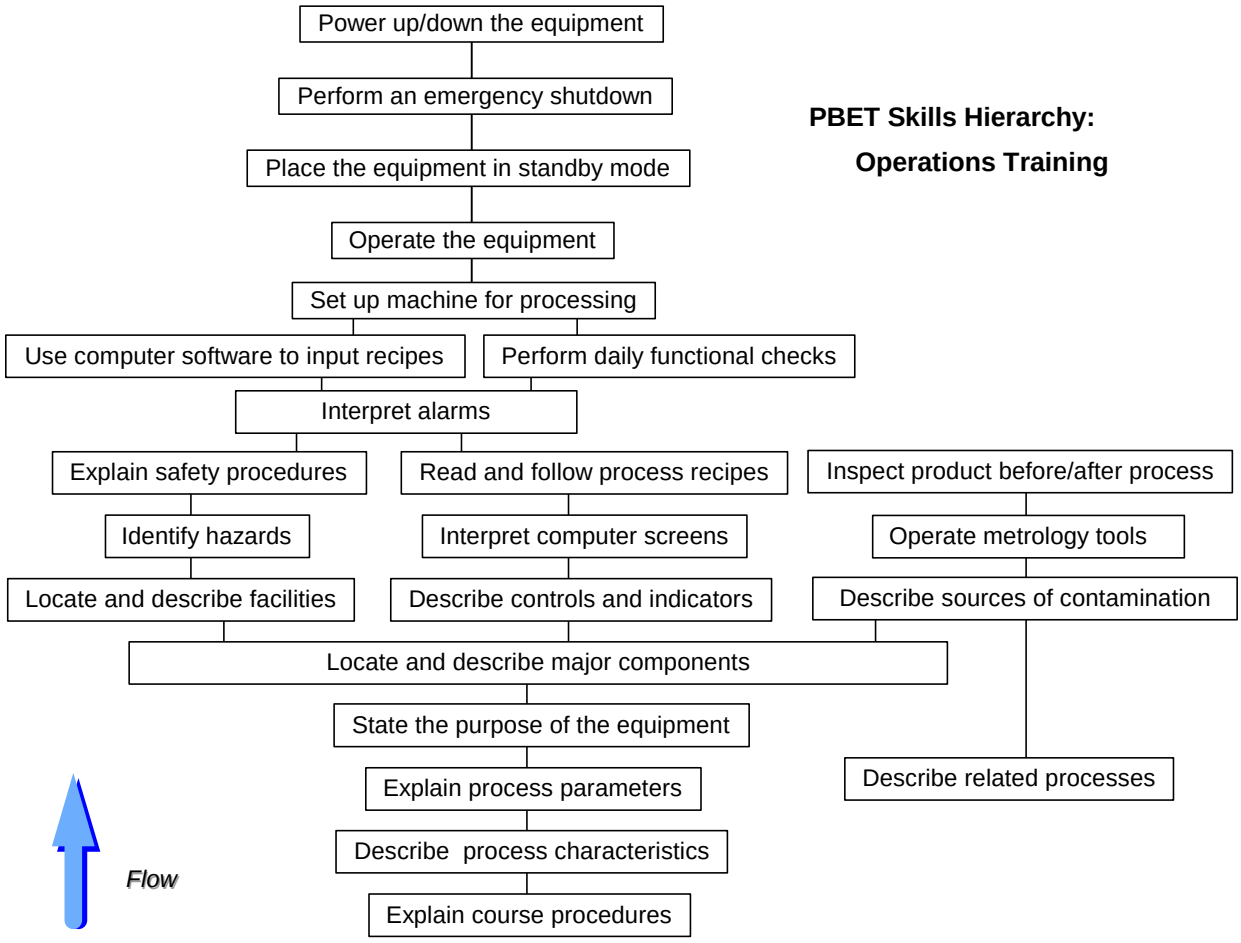


Figure 2 Course Map for Generic Operations Training

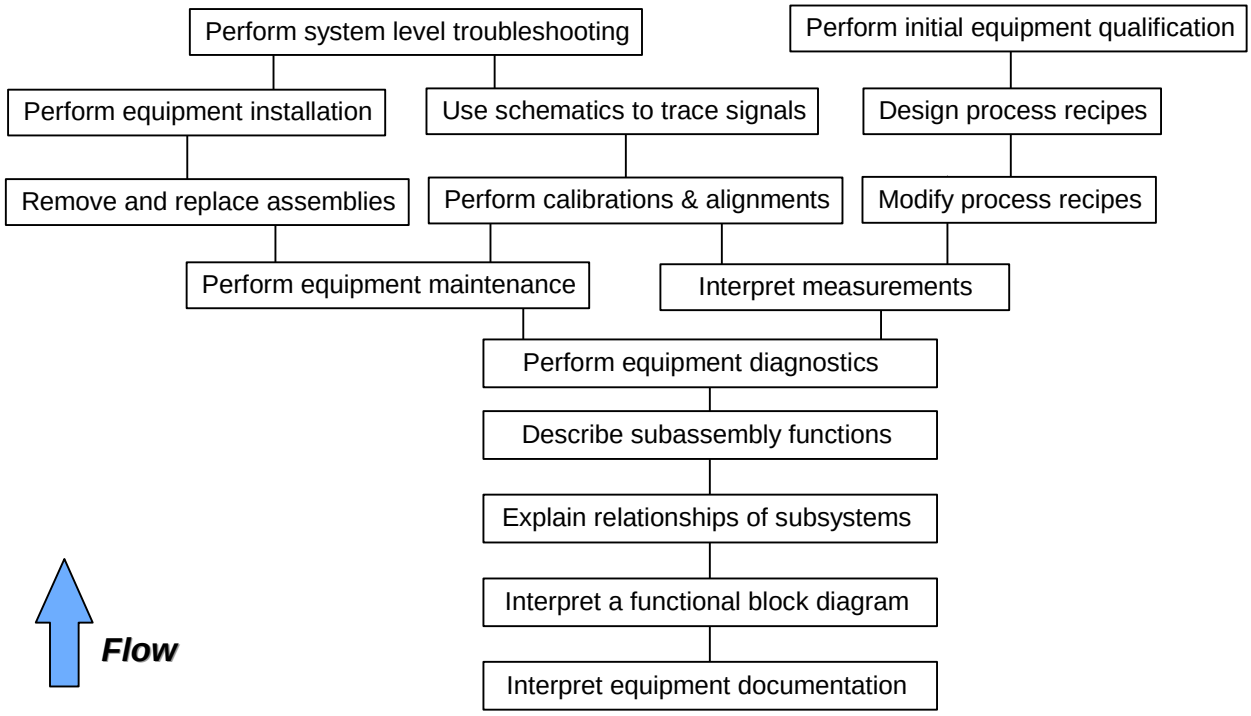


Figure 3 Course Map for Generic Service Training for Technician/Engineer

4 INSTRUCTIONAL STRATEGIES

4.1 Purpose

This section offers tips on developing instructional strategies for performance objectives or learning outcomes that have been identified in the analysis phase of the development process. It also contains a media chart which is an expansion to the Training Media Decision Chart in the *Performance Based Equipment Training* (PBET) course (The document is available on the Internet at www.tpic.org.).

4.2 Definitions

For the purposes of this section, instructional methods for the delivery of equipment training can be divided into two broad types: informational displays and practice exercises with feedback. These can be delivered through a medium or a mix of media. Computer-based training is a good example. Informational displays are presented on a computer screen and should be presented in a format compatible with the type of content (see Section 3).

- Procedures in a procedure or decision table
- Process in a WHEN-THEN table or a WHEN-IF chart flow diagram.

The learner can engage in practice exercises and/or tests and receive immediate feedback on his/her responses. Equipment training is usually delivered by content experts who are not instructional designers. Often, this training consists of lecture with overhead slides for the informational display and practice on the tool with feedback from the instructor or another content expert. Ideally, the media selected will be driven by the performance outcomes required;

however, selection of instructional methods will depend on many different considerations, some specific to the developer's own situation such as a lack of technical development resources. As for practice, there are few options as effective as practice on the tool. Simulations can be effective, if they can be designed to replicate the actual work environment.

Content type will also define practices. For example, see below:

If content type is:	Then practice is:
Procedure	Perform action in a job-related environment Solve problems by applying knowledge
Principle	Solve problems by applying guidelines, use case studies, role plays, and simulations

4.3 Delivery Strategies

There are four broad categories of delivery:

1. Self-paced with no instructor, via computer-based training (CBT) or interactive video disc (IVD).
2. Self-paced with instructor available, via CBT or self-paced workbook or video coupled with occasional feedback from instructor.
3. Instructor-led, with instructor in a classroom environment, using workbooks and other media. Equipment training should be delivered in a lab environment where a tool can be available for practice. Media usually includes overhead slides, schematics, equipment manuals and checklists.
4. Mentor led on-the-job training (OJT). Equipment and procedural training is delivered by a designated subject matter expert while using media such as guidelines, checklists and job related specifications.

4.3.1 Combinations

Often, a mix of methods and media is used to accomplish the instructional objectives. Table 5 contains a mix of methods and tools grouped according to instructor support. If part of the lesson needs to be communicated in the same way to everyone, a video can be used. Building the foundation knowledge can be accomplished at the trainees' home site before traveling to the site where the training will be taking place. CBTs can be used for this purpose, although they are much more expensive to develop; and unless they are developed by instructional technologists with the required expertise, the result is often an electronic book.

The information also could be delivered by using video clips and a workbook with exercises, questions, and answers made available when needed. Instructional development time may increase when the development is done by an instructional designer because the designer will follow systematic ISD steps and principles. The ratio of development time per hour of instruction will vary greatly, but the instructional designer should be allowed from 60 to 90 hours of development time for every hour of instruction. Equipment training development sometimes is accomplished in much less time by content experts; however, it may mean some parts of the systematic process have been omitted. A systematic approach would identify skills and knowledge required to perform each task (eliminating "nice to know" information) and would sequence the training properly in order to gain maximum efficiency. This will reduce the time it

takes the trainee to master the instructional objectives. Though the development time may be more, the time a person is off the job for training is reduced.

4.3.2 Instructor Support

The role of the instructor will be somewhat dependent on the tools and methods used, as Table 5 shows.

Table 5 Instructor Support Role with Methods and Tools

	Much	Some	Little
Tools	Textbooks Task List Reference Manuals Reading Assignments Reports Term Papers	Workbooks Training Manuals Practice Exercises	Programmed Instruction Computer Assisted Instruction Intelligent Tutorials Job Aids Peer Tutoring
Methods	Lecture Dialogues Demonstration Questioning	Discussion Role Playing Debate Open Forum	Brainstorming Focus Groups Guided Design Simulations Peer Tutoring

4.3.3 Using the Internet or Intranet as a Component of Delivery

An increasing number of people are using the Internet. You are invited to refer to the TPIC website (www.tpic.org) for updates from the eLearning and bLearning (blended learning) Task Forces. Because of the complexity of eLearning and bLearning and the changes resulting from technological advances, developers should first get questions answered by their company's Information Technology department. The most widely read training magazines have good, informative articles in each monthly issue and give relevant World Wide Web addresses. As a starter, you should visit the American Society of Training and Development's (ASTD) Web page at http://www.astd.org.

Table 6 Selecting Appropriate Media

Medium	Characteristics	Advantages	Disadvantages
Computer-Based Training (CBT)	• Interactivity with questions, responses, feedback • Self-study • Distribution to unlimited number of participants	• Cost effective for large audiences • Convenient for different work schedules • Mastery testing • Can be repeated as many times as necessary to learn material. • Little or no need for student materials.	• Prepackaged content may be generic • Most available packages heavy on text • Maintenance • Cost of hardware, software and development. • Cost of editing
Flip charts, White or Blackboards	• Spontaneous, diagrams, explanations	• High learner involvement • Low cost	• Varying legibility • Focuses instructor on writing • Requires thorough knowledge of subject
Interactive Video	• Customization and specificity • Enhancing CBT with photos, movies, sound	• Authenticity, job specific feel • Variety of scenarios on single disc • Can be repeated as many times as necessary to learn material.	• Cost hardware, software, development • Maintenance • Cost of editing • Not well understood by many customers
Job Aids	• Concise, specific guides	• No memorization • No writing • Available on the job where it is needed	• User dependence can lead to limited thinking • Can become uncontrolled document without ownership
Large-Screen Projection	• Displays real time computer screen • Can send teaching screen to learner's display • Link to projection for common focus	• Large group can see the same image • Can use student examples to teach specific points • Focal point for trainers & learners	• Eyestrain (poor resolution) • Competition between big screen and student monitors • Cost of hardware • Maintenance
Multimedia (CD-ROM)	• Combines text, video, sound • Simulates real world • Players readily available	• Combine CBT with video, sound • Allows for extensive interactivity or large amounts of information	• Development cost • Specialized equipment to write discs
Overhead Projectors	• All purpose, can substitute for flipchart • Addition of LCD panel can add technical sophistication	• Available in most classrooms • Flexible and portable	• Used excessively by some instructors

Table 6 Selecting Appropriate Media (continued)

Medium	Characteristics	Advantages	Disadvantages
Video Conferences	• Combines telecommunications, video, audio • Interactivity between instructors and students	• Geographically dispersed audiences • Can be recorded for later review • Suited to introducing new ideas	• Limited participation • Not good for procedural training
User Group/Bulletin Board	• Forum for discussion • Users share problem solutions • Access to common files	• Can assist with OJT • Broad base of expertise • Uniform software updates • User involvement	• Security, viruses • Telephone costs • Tendency to attrition after initial enthusiasm
Video	• Most popular alternative to classroom • Good for teaching repetitive programs • Inexpensive compared to classroom	• Standardization of content • Flexible viewing times • Authenticity • Less reading required • Can be repeated as many times as necessary to learn material.	• Good product can be costly to develop • Limited practice for student • Inflexible due to high cost of updates • Hardware costs
Distance Learning	• Train large audience. • Combines video, sounds, text, and instructor. • Entertaining if well designed.	• Reach a large audience. • Standardization of content. • Once initial investment is made, can be cost savings. • Saves travel expenses.	• Security problems. • Initial cost high. • Potential technical problems. • Interaction with instructor limited.
Internet/Network	• Access to the same information. • Content easily changed.	• Train large audience. • Standard material. • Update material easily. • Flexible viewing time. • Little or no need for student materials	• Security problems. • Expertise needed. • Ability to access.

Source: Elliot Masie and Rebekah Wolman, *The Computer Training Handbook*, (National Training & Computers Project: Raquette Lake, NY 1989)

5 INSTRUCTOR GUIDE FORMATS

5.1 What is an Instructor Guide?

The Instructor Guide is the documentation that guides the instructor in teaching the course. The Instructor Guide should contain performance objectives, notes defining class content, class schedule, and references to class materials.

An Instructor Guide is useful for both new and experienced instructors to make sure that the course is continuously delivered to achieve the course objectives that were published in the course description.

The Instructor Guide is a roadmap to ensure that each delivery of the class covers the same information, using the media designed for the class, and emphasizing the design objectives for the students.

Using an Instructor Guide ensures the following:

- Course is delivered in a consistent manner.
- Objectives are achieved and demonstrated.
- Appropriate technical information is conveyed.

5.2 What is in the Instructor Guide?

Following is a list of items that may be included in an Instructor Guide:

- Course agenda and scheduling of time
- Objectives
- Course outline
- List of course materials to be used
- List of equipment or models to be used
- Lesson plans
- Bullet point descriptions of the way each topic should be delivered
- Important points and facts to be presented to the students
- Key safety issues
- Student activities to be accomplished
- Identification of the points at which training media or manual references should be used
- Answer keys to tests
- Instructor cues and prompts
- Classroom and media setup
- Motivational tie-ins: anecdotes, analogies

5.3 Types of Instructor's Guides

The Instructor's Guide usually takes one of the following forms.

Instructor Guide Type	Description
PBET Lesson Planning Form	The lesson planning form provides a framework for designing and delivering a single lesson. A series of lesson plans can be used as an Instructor Guide when a formal Instructor Guide is not available.
2-page format (see *PBET Instructor Guide*)	In the 2-page format, the left-hand page contains instructor notes, and the right-hand page is the student guide.
2-column outline	In the 2-column outline, one column contains an outline of instruction, and the other column identifies instructor activities, media to be used, and training references.
Annotated student guide	The annotated student guide is probably the most common form of instructor guide. It can range from an informal collection of an instructor's hand-written notes, to a formal electronic document with hidden text for instructor notes. The hidden text can be turned on or off, depending on whether you wish to print an instructor guide or a student guide.

5.3.1 PBET Lesson Planning Form

<table>
<tr><td>Developer: Name of person responsible for developing this EST lesson</td><td>Equipment: Name of Specific Tool</td></tr>
<tr><td colspan="2">Lesson Title: Title of a specific lesson to be taught</td></tr>
<tr><td>Target Audience: Indicate who should perform this lesson?</td><td>Location: Provide the best and alternative location of where this lesson can be administered.</td></tr>
<tr><td colspan="2">Objective:
The performance objective or instructional objective is a clearly written statement that is understood by all performers. The objective is performance based, specific and measurable, and relevant to the requirements of the course or task to be performed. A well-written objective statement contains three important requirements.
1. Performance is the action that results from executing the task that's described in the objective.
2. Condition describes the environment, location, and/or situation where the performance is to take place, and it tells what materials, supplies, tools, equipment and resources may be used while performing the task.
3. The standard gives the acceptable level of performance. It may be stated in terms of how accurate the performance must be, how many times it must be performed, and how much time is allowed.</td></tr>
<tr><td colspan="2">Prerequisite Skills: List the skills that are necessary before the performers may participate in the training.</td></tr>
<tr><td colspan="2">Skill Test:
Any instructional system that utilizes well-stated objectives as a means of informing performers how they are expected to perform at the end of a course or a unit of instruction should have an accompanying well-matched skill test. The skill test measures the outcomes of the performance. The test must match the objective in terms of performance, condition, and standard.</td></tr>
<tr><td colspan="2">Additional Resources:
Given the requirements of the performance objective and the skill test, the instructional designer sets out to evaluate and diagnose the relevance and appropriateness of the material for the targeted audience. The designer determines if the material provides an adequate coverage of the subject matter. For example: Are there adequate examples? Are the skills and concepts adequately covered? Are there assumptions made that a learner might not understand? Is the language or reading level appropriate? Is it too technical, or not technical enough? If a performer tried the material, what would he or she think? Having examined the material, the designer determines what supplementary material is needed.</td></tr>
<tr><td>Training Aids & Media</td><td>Tools & Materials for Practice</td></tr>
<tr><td>Determine additional aids that will be required; for example, written procedures, flipchart, foils, photographs, models, etc. If possible, describe title of each aid and place them in numerical order as they are to be presented.
Note: SMEs and other qualified performers may be used as models or subject information.</td><td>List equipment, tools, and supplies that are required as part of the practice and final performance.</td></tr>
</table>

Figure 4 PBET Lesson Planning Form

Relevant Practice Description:

In this space, describe what the performers will be doing when they are practicing the intended *performance* that is stated in an objective.

The more we repeat an activity, the more chances we have of improving the outcomes of subsequent performances. However, the practice must be relevant to the stated objective.

A good relevant practice description contains four important ingredients.

1. *Performance*
2. *Conditions*
3. *Modeling*
4. *Feedback*

Conditions:

Describe how and with what the relevant practice is to be performed. In some cases, a similar activity may be substituted for the real relevant practice. Select the *best* and *alternative* methods for practicing the intended skill.

Type of Modeling:

Provide a way in which the performance can be demonstrated to a performer. The instructor or some other competent performer can model the performance. Various forms of media may also be used to model the performance; for example, pictorials, diagrams, sample practice sheets, videotape, and photographs.

Feedback Mechanism:

Wherever possible, provide indicators, signs, or cues that performers may use to measure their own performance. And if that isn't possible, provide a means for informing the performers how well they are progressing. The instructor can provide feedback, but other methods can also work as effectively; for example, video recording and still photography. Use also checklists, job aids, a list of correct responses, etc.

Summary of Module Content:

Describe the contents of the module so that other instructors can understand it enough to be able to teach it and manage it. In the summary include the following suggestions:

1. A description of relevance – what benefit will the module provide the participant?
2. Which teaching aids will be used at what time with which concepts?
3. Which skills are to be introduced, modeled, practiced, and tested?
4. The order in which specific concepts and skills are to be introduced.
5. The conditions in which the module is to be performed.

Figure 4 PBET Lesson Planning Form (continued)

5.3.2 Two-Page Format (for a single lesson)

Instructor Guide Page–left page

PBET SIMPLIFIED NEEDS ANALYSIS
Possible Solutions to Performance Problems

Each of the four categories of causes suggest their own solutions:

1. *Equipment problem* – may require re-engineering.
2. *Improper or inadequate incentives* – may require a change in the performance management system
3. *Lack of information* – provide feedback via: job aids, specs, manuals, signs, readbacks, expert systems, EPSS, and labeling
4. *Lack of skills* – provide practice, give instructions, provide training

Brainstorm Solutions to Performance Problems

• *Ask the audience to think of some possible causes for this performance discrepancy: Product is failing electrical test.*

– Lack of data or information

– Equipment or instrument problem

– Improper or inadequate incentives

– Lack of knowledge or skills

Student Guide Page–right page

PBET SIMPLIFED NEEDS ANALYSIS			
Identify the Performance Need		**Identify the Performance Solution**	
Informal Triggers	Formal Techniques	Possible Causes of Performance Problems	Possible Solutions to Performance Problems
– New standards, goals, or outcomes – New equipment, products, or processes – A readily apparent performance discrepancy	– Conduct observations – Conduct Interviews – Conduct surveys and/or questionnaires – Examine performance data	– Equipment problem – Improper or inadequate incentives – Lack of information – Lack of skills	– Re-engineering – Create or improve incentives – Provide feedback or job aids – Provide practice or training

PBET Module ID-1: Perform Needs Analysis

Each of the four categories of causes suggest their own solutions:

1. *Equipment problem.* An equipment problem requires re-engineering.
2. *Improper or inadequate incentives.* An incentive problem requires the creation, the improvement, or the elimination of certain incentives.
3. *Lack of information.* A lack of information requires that information be provided. This may be provided through on-the-job feedback. Or, it may be provided in the form of job aids which include: specifications sheets, manuals, signs, readbacks, expert systems, electronic performance support systems, or labeling.
4. *Lack* of *skills.* A lack of skills requires that an individual have a chance to receive renewed practice with feedback or a training program may be required.

Figure 5 PBET Instructor Guide (2-page format)

5.3.3 Two-Column Format

Module 1: Safety

Length: 02:00 hours

Materials Needed:

Student Materials:

1. Student Guide (SG) Module 1
2. System Overview (SO) Course Manual Module 1

Instructor Materials:

1. Instructor Guide

Classroom Materials:

1. Transparencies: System Overview transparencies Fig. 1-1 through 4. (See Master Course binder)
2. PowerPoint presentation Mod1.ppt Slides 1 through 6.
3. Overhead Projector
4. Computer & projection

Equipment Required:

1. None

Figure 6 Example of 2-Column Format for Instructor Guide

Topic Information	Instructor Activity
1.1 Welcome to Technical Training 1.1.2 Module Terminal Objectives Upon completing this module, the student will be able to: 1. Identify Safety hazard alert symbols. Distinguish between level of hazard and safety icons. 2. Identify electrical hazards and safeguards in the system. 3. Identify chemical hazards to include: a. What to do in the event of emergency. b. The standard gases in the system. c. The dangers of solid source chemicals. d. Acids and solvents. e. Lubrications and greases. 4. Identify mechanical hazards in the system.	 **Figure 1**  **Refer:** SG pp. 1-1,2
INTRODUCTION	
1. Read Objectives. 2. Create interest; involve class by asking for possible hazards. 3. Discuss reasons for Safety module: OSHA Downtime Injury Questions ?	 Instructor Activity– Write class suggestions on one side of whiteboard List reasons on other side of whiteboard
OUTLINE OF INSTRUCTION	
Topic 1: Safety Hazard Alerts State: Safety hazard alerts identify potential dangers and the consequences of not avoiding them. Refer students to Manual.	 **Reference:** System Overview (Safety) pages 1-1 through 1-18  **Refer:** SO pp. 1-1,2
Discuss overheads, as they relate to Objective #1: Alert label format**:** **DANGER**: *Will* result in *severe* injury or death.	 **Safety Hazard Alerts transparencies 2-4** **Figure: 2**
WARNING: *May* result in *severe* injury or death.	**Figure: 3**
CAUTION: May result in *minor* or moderate injury or product/property damage.	**Figure: 4**

Figure 6 Example of 2-Column Format for Instructor Guide (continued)

5.3.4 Advantages and Disadvantages for Each Format

Rank	Type	Advantages	Disadvantages
1	2-column outline	• Orchestrates the lecture and activities in a flow • Prompts are provided • Less bulky • Outline form less subject to change • All references are identified; coordinates when multiple references are used in the class	• Multiple documents may be required to teach the class • Time-consuming to develop
2	2-page format	• Good for a course to be used for a long time • A single document combines student guide and instructor guide • Long-term benefits • Stable content • Good for less experienced instructor	• Difficult to design & develop • Time-consuming; costly • Bulky due to student guide and instructor guide included
3	Annotated student guide	• Limited additional content or prompts are needed • Conditional or hidden text features can be included in the file • Only one document is created or needed	• If instructors create their own (not formally developed), consistency is lost • If a lot of information is required by instructor, difficult to include • Can be difficult to maintain student guide page order; all notes are maintained in an electronic file • Can be hard to standardize the course if multiple or changing instructors • If maintained in electronic file, must use a page layout program rather than just a word processor
4	PBET Lesson Planning Form	• Good for a short class • Short development time • Can have multiple uses: as a design document, a lesson outline, or as an instructor guide when a formal one is not available	• Intended as a design document or planning form, rather than for delivery • Very text-based; can be difficult to use during the class • Typically doesn't include foils or graphics • Not formatted for use in classroom delivery

6 EVALUATION METHODS

6.1 Purpose

This section is based on the Kirkpatrick model of evaluation which is most commonly used in the semiconductor industry. It begins with a brief review of the Kirkpatrick Model describing the four levels of evaluation and the tools and methods appropriate to the different levels. Each of the four levels is described along with examples or suggested approaches.

6.2 The Kirkpatrick Evaluation Model

Level	Issue	Questions Answered	Tools
One	Reaction	How well did they like the course?	Rating Sheets
Two	Learning	How much did they learn?	Tests, simulations
Three	Application	How well did they apply the training?	Performance Measures
Four	Results	What return did the training investment yield?	Cost/benefit analysis

Table 7 Kirkpatrick Evaluation Model

Level	Questions To Be Answered	Evaluation Methodology
1	1. How comfortable were participants? 2. Did they like the course? 3. How relevant was the course to their needs (job, work, responsibilities)?	• End-of-course evaluation sheets • End-of-course sheets & follow-up talks with students and their supervisors. • Ratings of each course objective (performance criteria) by students and supervisors.
2	1. How well did they learn the knowledge that was taught? 2. How well did they form the attitudes specified in the objectives? 3. How well did they develop the desired skills? 4. How much did they learn in the training?	• Mastery tests, usually paper and pencil, at key checkpoints and end of course. • Climate surveys – Measures of opinions, values, style, etc. • Observation of simulations – Role play – Lab demonstrations • Pre- Post- Test
3	1. How much of the training is actually being used on the job? 2. How has performance actually improved (hard data)? 3. How has performance perceptually improved (soft data)?	• Surveys • Interviews • Records on file (pre-, post-) • Direct observation • Surveys • Interviews • Reactions • Performance in simulations
4	1. How has training produced a return on investment? (Did it pay?)	• Cost/benefit analysis to examine money spent and saved (earned, produced).
1–4	1. How effective was the delivery (by instructor or self- study)? 2. How effective was the design in supporting the objectives?	• Evaluation by an expert qualified and respected enough to have credibility. • Evaluation of content, methods, media, strategies by a credible expert.

6.3 Level One Evaluations

Level one evaluation is a measure of the student's immediate satisfaction and reaction to a training session, and is often referred to as a smile sheet. A smile sheet does not measure knowledge gained or incoming knowledge, nor does it measure a student's ability to apply new knowledge/skills in the work environment. It does give an indication of the students' satisfaction with the learning environment, the personality and knowledge of the instructor, the delivery format, the appearance and appropriateness of the training materials, etc.

The purpose of this section is to show the following:

1. Examples of level one (reaction) evaluations currently in use
2. Examples of customized level one evaluations designed to give feedback on pilot training classes
3. How to get started designing a level one
4. When level ones should be administered

Many factors can influence the student's response to a level one evaluation survey. The student may have taken a personal dislike to the instructor, may have been forced to attend and is resentful, may not be feeling well and is not able to pay proper attention, may have poor reading skills or short attention span, and the list goes on. No matter how well the survey is written, there is no way to totally eliminate the ergonomic and emotional influences placed upon the student in the learning environment. It is important therefore to write survey questions that are specific and focused on the information required by the person writing the survey. The questions need to be worded simply with no ambiguity. Try to get straight to the point with as few words as possible. Avoid double-barreled questions that ask for an opinion in two separate areas, (i.e., "The instructor was knowledgeable and his delivery was appropriate.") This question is asking for two opinions: 1) Did the instructor know the material? and 2) Was he/she able to deliver the material in an effective manner? A single response would not evaluate both parts of this question, but a single response is what most students will give.

Grouping questions will make evaluating the surveys easier. Typical groupings are as follows:

- Course organization
- Course material and content
- Instructor knowledge and presentation skills
- Satisfaction of student needs

Most surveys use a numbering system (usually 1–5) to provide some type of quantitative measurement. In addition, there can be a space provided for written comments to verify the number selected. A "sanity check" section should be included to verify responses in areas that may be affected by student temperament and environment. Rewording previously asked questions to elicit a "second opinion" and doing a comparison can often eliminate emotional responses. Including a section for general comments is useful in obtaining unsolicited feedback and special requests for course improvement and direction-setting.

Following are examples of level one surveys. All currently are being used to gather data and are good examples of slightly different approaches to addressing the same issue. The above information and the following examples are "suggested" as ways to approach your need for level

one evaluation. Each application of this type of evaluation will be different based on many factors. Use this guideline as a starting point and customize your document to meet your needs.

An evaluation for trainee reaction allows the training organization to discover the satisfaction levels of the trainees who have taken the course. It answers the question: Were the trainees satisfied; did they like the training program?

Timing	Useful to Whom	Measurement Tool(s)	Responsibility for Measurement Design	Recommendation in Brief
Normally, at course conclusion	*Supplier*: Gets input for course design improvement and instructor improvement	• Reaction Form • Interview form (optional)	Supplier (Course designer and instructors)	Supplier should use existing models and research to create and use a form which provides input for revision of course design and delivery improvement.

6.3.1 Samples of Level One Evaluation Forms

EQUIPMENT COURSE EVALUATION

Course Name:_____
Student Name:_____
Instructor:_____
Supplier:_____
Date:_____Site:_____

To be filled in by instructor/Intel site training coordinator per class
Instructor ID:_____
Instructor/Owner Mail Stop:_____
Course Code:_____
Class Date: _____To:_____
Date Closed: _____Initials:_____
Product Owner:_____

Please bubble in your employee ID# here:

EMPLOYEE I.D.						
US	0	0	0	0	0	0
IR	1	1	1	1	1	1
EC	2	2	2	2	2	2
IS	3	3	3	3	3	3
PN	4	4	4	4	4	4
MO	5	5	5	5	5	5
M1	6	6	6	6	6	6
M2	7	7	7	7	7	7
M3	8	8	8	8	8	8
M4	9	9	9	9	9	9

INSTRUCTIONS

- Use #2 pencil or blue/black pen
- Darken bubbles completely
- Correct marks: ■■■■■
- Incorrect marks: • **X** ✓ ∅ ᗰ

Help us to improve the quality and effectiveness of this training by completing this evaluation. If you mark items "no" or "N/A", please explain in the comments section under the heading.

GENERAL INFORMATION:

1. What factory do you work in?

D1 D2 ET1 F4 F5 F6 F7 F8 F9 F10 F11 F12 F14
A1 A2 A4 A5 AETS FVC FEVS SVC T2 T7 T9 T11 T18
Other:_____

2. Describe at least two class highlights:_____
_____

3. Describe at least two class lowlights:_____
_____

4. What, if any, were your expectations of this training?_____
_____

5. Were your expectations met? No Somewhat Mostly Completely (N/A)

6. Based on your time, salary, and any travel costs, was Intel's money well spent on this training?

No Somewhat Mostly Completely (N/A) Can't tell

COMMENTS:_____

TRAINING FIT:

7. Are you a member of the target audience for this training (as stated by the instructor or in the course description)?
No Yes (N/A) Unable to judge

8. Was this training in your development or training plan?
No Yes (N/A) No development plan

9. Were the objectives aligned with your job performance needs?
No Somewhat Mostly Yes (N/A)

10. With respect to your current or future job needs, was this training available when you needed it?
No, I needed it 3 months later. Yes, right on time. No, I needed it 3 months earlier. N/A unable to judge

11. Did you complete the prerequisite classes and/or equipment experience?
No Somewhat Mostly Yes (N/A)

12. Are there any barriers that might prevent you from using the concepts and skills gained in this training back on the job?
Yes Somewhat Mostly No (N/A)

COMMENTS:_____

EQUIPMENT COURSE EVALUATION (continued)

Please answer the following questions according to this scale: If you rate an item a "1" or "2", please comment.	**SCALE** 1 = NO 2 = SOMEWHAT 3 = MOSTLY 4 = YES N/A = NOT APPLICABLE				
CONTENT/STRUCTURE:					
13. Prerequisite classes and/or equipment experience prepared me for this class.	1	2	3	4	N/A
14. Content supported the stated objectives.	1	2	3	4	N/A
15. Hands-on activities supported the training objectives.	1	2	3	4	N/A
16. Topics were covered in a sequence that helped me learn.	1	2	3	4	N/A
17. The duration of this training was: (1 = Too Long, 2 = Just Right, 3 = Too Short)	1	2	3		
18. The level of difficulty was: (1 = Too Easy, 2 = Good, 3 = Too Hard)	1	2	3		
COMMENTS:_____ _____					
MATERIALS:					
19. Text and materials supported the objectives.	1	2	3	4	N/A
20. The performance measures (tests, checklists, homework, etc.) matched the objectives.	1	2	3	4	N/A
21. Materials were "up to date."	1	2	3	4	N/A
22. Overheads/handouts/videos were easy to understand.	1	2	3	4	N/A
23. Specs, manuals, and other documents were available as needed.	1	2	3	4	N/A
COMMENTS:_____ _____					
FACILITIES/EQUIPMENT:					
24. Room and lab space were sufficient and promoted learning.	1	2	3	4	N/A
25. The tool (machine) used during hands-on was the same as the tool used on the job.	1	2	3	4	N/A
26. The tool (machine) was functional/usable.	1	2	3	4	N/A
27. Supplies needed for hands-on were available (tools, fixtures, wipes, wafers, etc.)	1	2	3	4	N/A
COMMENTS: _____ _____					
INSTRUCTOR:					
28. Met the stated course objectives.	1	2	3	4	N/A
29. Gave safety guidelines and followed them.	1	2	3	4	N/A
30. Demonstrated thorough knowledge of the subject matter.	1	2	3	4	N/A
31. Presented technical matter clearly.	1	2	3	4	N/A
32. Answered or followed up on questions.	1	2	3	4	N/A
COMMENTS: _____ _____					

6.3.2 Customized Level One Evaluations in Pilots

Customized level ones are sometimes called participant feedback sheets because they are used to get feedback on what parts of the pilot work well and what parts need to be revised. Because they are used to improve training, they are called formative evaluations. You can also use them to identify barriers to the transfer of learning to the workplace. These forms are improvement oriented and can follow any design you may create to capture the information you or your customer needs. Examples follow.

6.3.3 Example of Generic Template

The template that follows can be modified for many types of classes. Although this Likert scale measures how well the objectives were met, it could also be modified to measure how effective materials in each module are or how important each module is in preparing the trainee to perform the terminal performance objective (TPO).

1 = Not effective/important

2 = Somewhat effective/important

3 = Effective/important

4= Very effective/important

Table 8 Generic Level One Evaluation

Title of Class_____Date_____ Instructor_____				
Please rate the class on how well the following objectives were achieved:	1	2	3	4
A				
B				
C				
D				
E				
Please explain any ratings below 3 in the space provided below: _____ _____ _____ _____	**Rating Scale** 1 = Did not achieve objective. 2 = Achieved to some extent. 3 = Achieved objective. 4 = Exceeded expectations.			
How do you rate the balance of lecture and activity (hands-on practice) or lecture and group discussion and group exercise? ____A. Too much lecture ____B. Too much discussion ____C. Too many exercises ____D. Good Balance (right amount of lecture and hands-on or lecture and group discussion/activity.	Please list any barriers that would prevent you from going back to work and applying skills learned in the class. _____ _____ _____ _____			
The best thing about this class was: _____ _____ _____	The class would have been better if: _____ _____ _____			

Table 9 Example of Emergency Response Team Customized Level One

Circle the correct information or fill in the blank

Fab: 17 18 19 Other: _____						
ERT: Leader Member						
Time on ERT:						
	Document	**Easy to Use? Y/N**	**Will use on the job? Y/N**	**Value Added? Y/N**	**Barrier to Use? Y/N**	**Please comment**
1	**HASP**					
2	**GRP**					
3	**Evacuation**					
4	**Odor**					
5	**Outdoor**					
6	**Person Down**					
7	**BBP**					
8	**Flow Switch**					
9	**Fire/Smoke**					
10	**Fire Pump Run**					
11	**LSS**					

Use this scale for the questions below:
1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree

	The course in general	**1**	**2**	**3**	**4**
1	The background information (ERT structure, R & R, priorities) is useful.				
2	The course content is useful to a new ERT member.				
3	The materials succeed in meeting the course objective: to prepare ERT members for an emergency response.				
4	The modules (Structure, Priorities, Training, GRP, HASP, Specific Response Protocol & Scenarios) contributed to the course objective.				
Comments: Are there any that stand out–good or bad?					
	The Scenarios	**1**	**2**	**3**	**4**
1	The scenarios provided good practice using the HASP, GRP and other response protocol.				
2	The scenarios were structured well.				
3	The scenarios will help me be prepared for an incident response.				
Comments: Are there any that stand out–good or bad?					
	Instructor	**1**	**2**	**3**	**4**
1	The instructor provided the right amount of detail.				
2	The instructor assessed the target audience experience level in the class and modified instruction accordingly.				
3	The instructor was able to provide relevant information.				
4	The instructor provided adequate feedback.				
5	The instructor facilitated the scenarios well.				
Comments:					

Table 10 Example of Behavioral Accident Prevention Process

BAPP Observer Training Participant Feedback Sheet **Part One: Achievement of Objectives**

Student #_____ Date:_____

Instructor_____

CLASS OBJECTIVE: Be able to perform an observation in your own area with 100% accuracy.

Instructions: In order to perform the above class objective, you must be able to perform the sub-objectives. Below is a list of some of the specific skills/knowledge needed to perform the sub-objective. Beside each item, please use the rating scale that best describes how you feel about the item.

With the training given in this class and the job aids I can take with me,

1. I can't do this.
2. I am not sure if I can do this.
3. I think I can do this, but it might take some time (to look up, etc.)
4. I am sure I can do this with no problems.

		1	2	3	4
Objective: Be able to explain the purpose, background, and accomplishments of BAPP.					
Explain purpose					
Explain accomplishments					
Explain BAPP Core Team structure					
Objective: Be able to identify barriers to working safely, safe, and at-risk behaviors.					
Give a couple of examples of barriers					
Distinguish between a safe behavior and an at-risk behavior.					
Define BAPP Terms:	Critical Behavior Inventory (CBI)				
	Situational Centered Observation				
	Behavioral Centered Observation				
	Comment				
Objective: Be able to perform observation in your own area and fill out paperwork correctly.					
Perform the introductory phase steps correctly					
Get supplies and find person to observe					
Do an area scan					
Fill out all required entries for the introductory phase.					
Perform observation phase: Situational					
	Behavioral				
fill out data sheet:	Mark safe or at-risk				
	Write the "what" comment				
	Write the "why" comment				
Perform feedback Phase: Use 3 "why" technique					
	Write clear comment if req'd				
Objective: Be able to demonstrate good communication skills to encourage cooperation from the person being observed.					
Establish rapport					
Be prepared to handle negative reactions					
Avoid words or behaviors that work against you					
Objective: Be able to explain how BAPP data is used to reduce accidents.					
Explain how comments can lead to fixes					
Explain how comments can lead to prevention					

Table 10 Example of Behavioral Accident Prevention Process (continued)

<table>
<tr><td colspan="2">Part Two: Tools and Techniques</td></tr>
<tr><td>Please use the scale at the right to rate the items listed below that were used in the class. Tell us what tools/techniques were useful as an aid to learning; feel free to make suggestions for improvements.
Tool/Technique Rating Suggestion
Observation flow chart _____ _____
Flow chart in 3 phases _____ _____
Video as demonstration _____ _____
Barney/Betty BAPP _____ _____
Matching at-risks & definitions _____ _____
Comment scoring exercise _____ _____
Feedback exercise _____ _____
Field trip _____ _____
BAPP Jeopardy _____ _____</td><td>Rating Scale
1 = Not useful – trash it
2 = Somewhat useful – keep, but needs work
3 = Useful – keep, but could use improvements
4 = Very useful – keep as is
5 = Don’t remember</td></tr>
<tr><td>How do you rate the balance of lecture, group discussion, and group exercise?
____A. Too much lecture
____B. Too much discussion
____C. Too many exercises
____D. Good Balance

What suggestions would you have for the instructor?</td><td>Please list any barriers that would prevent you from going back to work and applying skills learned in the class.</td></tr>
<tr><td>The best thing about the class was.....</td><td>The class would have been better if.....</td></tr>
</table>

Table 11 Customized Form to Evaluate a Supplier's Hands-On Class

Fab:_____ LT = Lack of Time Job Title:_____ T = Tool Functionality					
Tasks (Answer for each task listed below)	**Did you practice this task? Y/N**	**If Y, was practice sufficient? Y/N**	**If Y, was knowledge sufficient before you practiced? Y/N**	**Mark LT or T (reasons) beside tasks you did not practice**	**Check any tasks that are not done in your factory**
1. Remove the.....					
2. Calibrate.....					

6.3.4 Administering Customized Level One Evaluations

The problem with using the generic level one forms provided by the company is that the developer is unable to determine specific information relative to different sections of the class. A focus group is needed or follow up with participants to get concrete information. However, designing and using customized forms gives specific data on which to base revisions. Forms should be designed to be administered after meaningful sections of the class while the information is fresh in the minds of the participants. For a one-day class, the evaluation might be designed in two parts. The first could be administered before the lunch break and the second at the end of the day. If the class is more than one day, evaluations should be administered daily or more often.

6.4 Level Two Evaluations

Level two evaluations measure the successful performance of training objectives. The most common form of level two evaluation is the test.

Evaluating for trainee *learning*, as it relates to semiconductor technicians, may be further defined as evaluating for the following:

- Skill acquisition
- The ability to perform to standard
- Competency

The key question is: Did the trainees gain competency in the stated skill objectives?

The best way to evaluate for skill acquisition is to observe a demonstration of the trainee's competence in performing the skill. As such, a "test" in equipment-related training courses should consist of a trainee's demonstration of pre-designated skills.

Each performance objective should have its own test item in which the learner has the opportunity to demonstrate competence. A performance-based test item must match the requirements of its performance objective.

The drafting of test items should immediately follow the drafting of and agreement with the list of performance objectives. This assures that the individual test items, taken together, reflect

absolute agreement with the performance objectives and the analysis of the performance discrepancy that prompted them.

The purpose of this section is to offer tips on writing tests for level two evaluations that will pass validity and reliability checks.

Content includes the following:

- Using level two learning evaluations in pilots
- Legal issues: Disparate impact and disparate treatment; sole determinative factor
- Validity: The test does what it was designed to do
- Reliability: The test performs the same way each time
- Matching tests to domains and levels within domains
- Structures that can be employed in tests
- Guidelines for writing test items

6.4.1 Using Level Two (Learning) Evaluations in Pilots

As a check to see if the information presented in the class is being retained, numbers can be assigned to the participants on pre-tests and the same number on post-tests in order to measure information gain. Participants need to be told that this is a check on the class, not on them, and that their anonymity is guaranteed. The test itself should have been piloted before use to make sure it meets the following criteria (covered in the next section):

- Tests the *objectives* which are clearly stated and measurable (tests for the skills and knowledge needed to perform the objective).
- Meets a clear purpose (measures information gain).
- Its *structure* (paper/pencil, scenario) and *item type(s)* (multiple choice, true or false) are appropriate to test the skills and knowledge.

6.4.2 Legal Issues and Test Results

Increasingly greater emphasis is being placed on minimizing the legal risks involved in testing employees. Certification tests, in particular, have the potential to cause legal action to be brought against a company if certain types of personnel decisions result from the score a person receives on a test. If a case goes to court, the company would have to defend the test as being valid and testing the skills required for the job. This can be a lengthy and expensive process.

Discrimination and the use of test results are two of the most frequent problems that initiate legal action. Discrimination usually occurs in two areas:

1. Disparate Impact
2. Disparate Treatment

The word disparate means to separate. In the case of testing, it means to separate test takers or the results of tests taken into different categories based on something other than legitimate test content and results.

6.4.2.1 Disparate Impact

Disparate impact results when the instructor or test problems cause some people to score differently from others because of their race, color, religion, sex, national origin, age, or handicap.

When the results of a test are used in transferring, hiring, promotion, or other personnel-type decisions, and the test has disparate impact, then the impacted group is being treated in an unfair fashion. ***Example:*** If a test is designed such that females with the same training and background as males continuously receive lower scores, the test has a design flaw allowing for this disparate impact (the impact being lower, perhaps non-passing, scores that may result in disparate treatment.) A test of this nature is not *reliable* (will not perform the same) when it comes to testing between males and females.

6.4.2.2 Disparate Treatment

Disparate treatment means the employer treats some people differently from others because of their race, color, religion, sex, national origin, age, or handicap. This is intentional discrimination.

6.4.2.3 Sole Determinative Factor

In the areas for which we most commonly write tests, there is one area that can be a serious problem—making the test the sole determinative factor. This means that once a person has taken the test, it becomes the only item looked at to determine whether this person can continue with the program/career ladder/etc., or whether this person must pursue another direction.

If there is no chance for a trainee to challenge a test, or receive remediation, then the training organization is limiting this individual's potential for future growth. It is important to make sure that the test that is being given is not the only factor used in determining the direction a trainee must take. It should be only one of many ways in which this decision is made. Remediation should also be available to those who fail tests.

6.4.3 Validity and Reliability

Two sets of questions must be asked about any test:

1. Is the test *valid*?
   Does the test do what it was designed and constructed to do?
2. Is the test reliable?
   Can the test be trusted to perform the same each time you use it? The test can be reliable even though it may not be valid.

6.4.3.1 Types of Validity

Types of validity are as follows:

- Content Validity
- Face Validity
- Predictive Validity

6.4.3.1.1 Content Validity

The test evaluates content in a way *consistent with the nature of the content*. If the content is to pound a nail into a piece of wood with a hammer, the test should test an individual's ability to perform that action. Assumptions are part of the content of the test. If testing ten people, one at a time, you cannot assume that the last person has not gained information from the first nine persons tested; such a test may not have content validity.

6.4.3.1.2 Face Validity

The test should *look like a test*. If it is a performance test (not paper and pencil), the administrator should state, "This is a test." In addition, a test should test trainees on what they are *expecting* to be tested on. If the test tests to *criteria taught in the class*, it has face validity. The trainee must feel that the test tests *relevant criteria*.

6.4.3.1.3 Predictive Validity

The test can accurately predict future competence. This test often is used in personnel selections. *Soft skills* can be very difficult to measure by observation. Some skills may be difficult to observe, such as problem solving. These types of skills should be checked in ways where the test taker is presented with a problem and asked to solve it. Skills like effective listening can be observed and measured. *Hard skills* are demonstrable skills and predictive validity can be easily established. A trainer can ***observe*** a trainee perform new skills.

6.4.3.2 Reliability

A test is reliable when it tests the respondents in the same way each time the test is administered. A test has reliability if the conditions below apply:

- The test performs the *same way each time it is used* (i.e., for a target population with similar backgrounds, similar results should be seen).
- A person who is skilled in the area being tested should score well. A person not skilled in the area tested should not score well.
- The score expectations should *remain true over a period of time*. If the scores remain consistent for the same type of test takers, the test is reliable. If there are deviations as to how well the test performs over time, it is not reliable.
- Assuming that a test is reliable may cause significant problems, particularly if someone's job or career plan is put in jeopardy by failing a test that he/she should have passed.

6.4.3.3 Job Analysis

The job analysis identifies the skills/knowledge that should be tested. It also helps in identifying which items should be tested by a paper and pencil test and which items should be tested using an observation checklist. The "Job Knowledge" and "Cognitive" areas are usually tested on paper. The "Tools Used on the Job" and "Activities" are usually best tested by using an observation checklist.

Table 12 Job Analysis Example

Job Knowledge	Tools Used On The Job
Specifications Vendor Manuals White papers "Copy Exactly" Performance Objectives	WorkStream Automated Response Flow Charts Gauges/Indicators Knobs/Adjustments Wrenches Statistical Process Control (SPC)
Cognitive (What's Thought)	**Activities (What's Done)**
What are the parameters? Which knob do I use to make the proper adjustment? I need to run a test wafer after making this adjustment. How do I plot this on the SPC chart?	Read the flow indicator Adjust for correct flow ±.2 cfpm Turn the knob ¾ of a turn counterclockwise Plot results on the SPC chart

6.4.3.4 Domains

In determining how to develop a test item, identify the *domain* or sphere of knowledge in which the information or skill resides. Also, identify at which level within that domain the skill resides. If you know the domain, you then can begin the process of determining the item type (multiple choice, matching, etc.) that would be best. The Recall level is basic knowledge. The Application level is use of that basic knowledge to do something familiar. The Developmental level is use of that knowledge to do something that one may not have done before. The domains and levels are in Table 13.

Table 13 Domains

DOMAIN →	Cognitive	Affective	Psychomotor
LEVEL ↓	Thinking, ideas, opinions	Emotions, values, attitudes	Physical acts & conditions
RECALL (What)	A person remembers information. The information is not changed nor processed.	An emotion, value, or attitude is recalled without change.	A physical movement is repeated. A sight or sound is recognized.
APPLICATION (How)	A person uses information in a process. Thinking conforms to previous patterns.	An emotion is directed toward a person or thing. A value is used to justify an action.	A physical skill used to achieve an end. A sound or other stimulus is produced.
DEVELOPMENTAL (Why)	A person uses information to solve a problem or develop new ideas/applications.	Emotion is used to achieve a new goal. Values are modified to accommodate new data.	A new skill area is begun. An old skill is used in a new arena. Higher levels are gained.

Normally, a test is developed for specific knowledge or skills that impact a single domain at a particular level. Table 14 shows how the impact of domains can affect item type selection.

Table 14 How Domains Affect Item Type Selection

DOMAIN →	Cognitive	Affective	Psychomotor
LEVEL ↓	Thinking, ideas, opinions	Emotions, values, attitudes	Physical acts & conditions
RECALL (What)	What are the names of the people on my defect team?	What is your feeling about scrapping one wafer?	Show your trainer the nearest emergency exit.
APPLICATION (How)	How much should I turn the knob to increase the gas flow to match the spec?	Is it fair for my supervisor to run my 1:1s every time we meet?	Take the lot to the next step in the Litho operation.
DEVELOPMENTAL (Why)	How will John's hospitalization affect our responsibilities on the floor?	How can I use a "total lifestyle" concept to instill an understanding of the dangers of working with hazardous chemicals?	Determine what operation/area is causing a defect on a previous layer, and communicate the problem to that operation/area.

6.4.3.5 Test Structures

Various structures can be used, depending on the domain of the objective needing to be tested and the purpose of the test. See the examples below:

- **Paper/pencil test–**a pencil and paper are the only tools needed to complete the test.
- **Performance test**–usually an observed set of behaviors/skills.

- A **scenario** can be given verbally or written. The answer can be provided by the trainee as verbal or written as well. A scenario is a situation in which the trainee is asked to place him/herself in a particular situation and solve a specific problem.
- A **verbal quiz** can take place on the job, or in a neutral environment. Generally, this is to check for cognitive skills of an individual. It replicates a situation, for example, in which a technician may be asked of another technician how s/he fixed a particular problem on a piece of equipment. Some of the questions may include "why" questions to get at what thought processes the tech used to identify the "how" of fixing the problem.
- A **role play** is usually a classroom procedure. In a role play, specific roles are given to various individuals. One or more of the individuals are being observed for their actions in the given situation.

6.5 Guidelines for Writing Test Items

6.5.1 Multiple Choice

Multiple Choice is perhaps the most common test item type used both in education as well as in industry. It may look simple to construct. However, a correctly designed multiple-choice question takes time and each component is important.

There are three components to a multiple choice test item:

- **The stem–**the main statement that is completed when the correct answer is chosen.
- **The correct answer**
- **The distractors–**several alternative answers to the correct answer.

6.5.1.1 **The Stem** (the main statement)

When writing the stem sentence:

Do:

- Use the clearest and simplest language possible.
- Place as much wording in the stem as possible, rather than in the alternative answers.
- Use ***italics and bolding*** to highlight negative words (***no***, ***not***, ***none***, etc.) That are needed in the stem.

Avoid:

- Redundant wording by placing common phrases in the stem and wording the alternatives so that they follow from the stem sentence.

6.5.1.2 The Correct Answer

Do:

- Ensure that the answer corresponds with the training received. Verify the correct answer from training materials, the instructor or content experts who are performing the job properly.

Avoid:

- Including irrelevant information that would distract a person from selecting the item.
- Placing the answer in the same position among the distractors for every item. Keep selection as random as possible.
- Making the answer much shorter or much longer than the alternatives. This often gives away the answer as it attracts the attention of the test taker simply by "sticking out."
- Using "all of the above" or "none of the above" as the answer. If you must use "none of the above," use it as the answer one-third or one-fourth of the time that it appears.
- Using "both a and b are correct" or "a, b, and c but not d are correct." Such items tend to test a specific ability called "syllogistic reasoning," aside from the content pertinent to the item.

6.5.1.3 The Distractors

Do:

- Provide three or four alternative answers including the correct response. Items with different numbers of alternative answers can appear on the same test.
- Make all alternatives grammatically consistent with the stem of the item to avoid cueing the correct answer.
- Use incorrect paraphrases and familiar-looking or verbatim statements that are incorrect answers to the question.
- Use true statements that do not answer the question.
- Use common errors that trainees make in developing distractors: anticipate the options that will appeal to the unprepared test-taker.
- Use job-related technical terms.
- Check the items to ensure that the options or answer to one item does not cue test-takers to the correct answer of the other items.

Avoid using:

- Specific determiners such as all, always, never.

6.5.2 Examples Of Well-Written And Poorly-Written Multiple Selection Items

Poor

1. Underline each defect found at Final Check:
    a. Scratched photoresist
    b. Unetched
    c. Unimplanted
    d. Misaligned
    e. Overetched
    f. Dropped wafer
    g. Incomplete clean

h. Excess nitride
i. Underetched
j. Particles

With this item, the test taker may underline all items listed (except “Unimplanted,” which cannot be seen, and “Dropped wafer,” which is a guess as to the cause of a problem found on a wafer). The stem does not give sufficient information as to which defects are being looked for. In that case any defect that could possibly be found at Final Check can be selected as a correct answer. In effect, this opens up the selection to virtually all defects.

Following is an example of a better way to identify if your trainee knows which defects, caused in the Etch area, are *commonly* found at Final Check. Note that the word “common” is italicized to emphasize the common defects from the less common. (Of course, the “common defects” must have been taught specifically in the training program, otherwise this question is invalid.) This stem effectively omits defects found at Develop Check, or other problems only identified by an electrical test or at Sort (such as a missing implant, etc.). Also, information about the scoring of this specific item is provided.

Good

2. Underline each example of *common* Etch area defects found at Final Check. (One point will be given for each correct selection.)
   a. Scratched photoresist (The *result* of this may be commonly found, however to select it would indicate a guess as to the cause, not the defect itself.)
   b. Unetched
   c. Unimplanted
   d. Misaligned
   e. Overetched
   f. Dropped wafer
   g. Incomplete clean
   h. Excess nitride
   i. Underetched
   j. Particles

6.5.3 True/False Items

Use true/false items in situations where there are only two likely alternative answers, i.e., when the content covered by the question is dichotomous. Include only one major idea in each item. Make sure that the statement can be judged reasonably true or false. Statements should be as short and simply stated as possible. Avoid negatives, especially double negatives; highlight negative words {for example, ***not***, ***no***, ***none***) if they are essential. Any statement of opinion should be attributed to its source. Randomly distribute the true and false statements. Avoid specific determiners (for example, always, never) in the statements.

6.5.3.1 Examples Of Well Written And Poorly Written True/False Items

Good

1. ____ Blank wafers are only comprised of silicon.

False. A blank wafer may have had another material deposited on it before being processed through the Litho and Etch areas. This is an example of a well written true/false item.

Okay

2. ____ Blank wafers have no pattern because they have not gone through the Litho area.

True. However, this is an item that should only be used for a new employee not familiar with the industry or someone not familiar with basic fab processes.

Poor

3. ____ The XY product produces more profits for company X than the Product XX® because they are more expensive than the XX product. The output is also lower on Product XX than Product XY®, resulting in more profits for Company X from the Product XY®.

False, and then True. This violates the guideline of having only one major idea in each item. It's also lengthy for a true/false item. Using the "because..." phrase provides some thinking that you may want the trainee to do, rather than provide it in the test item (even though that is what makes the first statement false).

Good

4. ____ The Product XY® produces more profits for Company X than the Product XX®.

5. ____ The Product XX® output is lower than the Product XY®.

These two items correct the problems associated with item #3. They contain single items and require the trainee to think about the statement and factors that may make it true or false.

Poor

6. ____ "Assumed Responsibility" at Company X means that you assume that someone has the responsibility for something.

This item is vague. It is true that "you assume that someone has the responsibility for something." However, in Company X's culture, it means that you take initial responsibility for a problem that you notice. The item is invalid due to its vagueness. It may be answered True or False by various individuals.

Good

7. ____ "Assumed Responsibility" at Company X means that someone assumes responsibility for a problem that their supervisor should handle.

This is a clear statement about "assumed responsibility" at Company X, although False. (Discipline is a problem that you should not assume responsibility for. Supervisors/managers are directly responsible for those issues.)

Poor

8. ____ You should not scratch your face while wearing a chemical glove even if the glove has not been used.

This item contains two "nots." They are not highlighted in any way (italics, bolding, etc.). The "... even if it has not been used" phrase may not be necessary. The problem is scratching one's face while wearing a chemical glove, not whether the glove has been used.

6.5.4 Matching Items

Matching items present test-takers with two lists of words or phrases and ask the test-taker to match each word or phrase on one list to a word or phrase on the other. These items should be used only to assess understanding of homogeneous (similar) content. Matching items most frequently take the form of a list of words to be matched with a list of definitions. Matching items are relatively easy to write. However, one reason for this is that they do not assess beyond the comprehension level.

- Include only homogeneous, closely related content in the lists to be matched.
- Keep the lists of responses short: five to 15 entries.
- The response list should be arranged in some logical order, e.g., chronologically or alphabetically.
- Directions should clearly indicate how often a response can be used; responses should be used more than once to reduce cueing due to the process of elimination.
- Use a different number of responses than entries to be matched in order to reduce the process of elimination cueing.
- Place the list of entries to be matched and the responses on the same page.

6.5.4.1 Examples Of Well Written And Poorly Written Matching Items

Poor

Match the following by placing the letter of the answer to the right in the space next to the item at the left.

1. ____	Water that has been de-ionized.	A. A scribe line
2. ____	A line separating the different die or "chips" from each other.	B. A die
3. ____	An object that deionizes particles in the air of a workspace.	C. A notch
4. ____	The software package that is used to track the stream of work in the fab.	D. A wafer
5. ____	Not a blood product, but an electrified gas.	E. A plasma
6. ____	An indentation on the wafer for orientation purposes.	F. A HEPA filter
7. ____	Many die or "chips" are created on one of these.	G. DI water
8. ____	This is used to carry an entire lot of wafers.	H. A workspace deionizer
9. ____	A High-Efficiency-Particulate-Air filter.	I. A lot box
10.____	Also known as a "chip"	J. WorkStream

This is a very poor example of a Matching test item. The numerous problems include: There is no indication in the instructions on whether an answer can be used more than once; there is cueing in a number of the answers (for example, “Not a blood product, but... “ is an example of many persons experience with the word “plasma,” or “Water that has been de-ionized” is very obviously the answer to #7, “DI water”); the number of answers is equal to the number of entries to be matched, allowing for a process of elimination.

The following is a better example of a matching test item.

Good

Match the following by placing the letter of the answer to the right in the space next to the item at the left. An answer may be used more than once, and all answers may or may not be used. All items must have one letter in the space before them.

1. ____	Laminar air flows through this for final purification before entering the fab.	A.	A scribe line
2. ____	Also known as a “chip”.	B.	A die
3. ____	This is used to track the progress of a lot of wafers through the fab process.	C.	A notch
4. ____	This is used to orient the wafer for various fab processes.	D.	A wafer
5. ____	The wafers are protected by this when in transit or storage.	E.	A HEPA filter
6. ____	This separates the various die on a wafer from each other.	F.	A lot box
7. ____	Used to pick up a wafer manually.	G.	WorkStream
8. ____	Many microprocessors are built upon and in this.	H.	A microprocessor
		I.	The major flat
		J.	Lot box slot

This is a better example of a matching test item. Some of the positives include a different number of responses for the items at the left; use of items “B,” “D,” and “E” more than once (for numbers 2 and 8, and 3 and 9, and 6 and 10 respectively); option “G” is a distracter and should not be used by an informed test taker as an answer; all matches are in relation to wafer parts and basic wafer processing; the answers are clear and will not be confused by a well-trained (informed) test taker.

6.5.5 Performance Tests and Checklists

Performance tests involve the rating of a behavior. A valid performance test is based on a detailed and thorough analysis of the skills required for the behavior. Once the behavior has been analyzed to define the essential characteristics of worthy performance, the next step is the creation of a rating scale to support a final evaluation. There are four types of rating scales: numerical, descriptive, behaviorally anchored, and checklists. Of these four, numerical and descriptive scales are not recommended due to possible rater subjectivity. Rater subjectivity means that the person scoring the performance may have a bias toward the individual, for whatever reason. Behaviorally anchored scales or checklists are acceptable approaches to assessing a skill or product, but of these two, the checklist is generally more reliable.

6.5.5.1 Numerical scale

Numerical scales divide the evaluation criteria into a fixed number of points defined only by numbers. Typically, the extremes are labeled with a descriptive word, but usually not anchored to the behavior being observed. There is no definition of what level of performance merits a particular numerical rating. For example, what does a "3" mean on a 7-point scale? This is highly subjective and can introduce substantial error.

Table 15 Example of Numerical Rating Scale

Behavior	Performance			
	Poor			Excellent
	1	2 5	3 6	4 7
1. The peer trainer used reflective listening skills with the trainee	1	2 5	3 6	4 7
2. The peer trainer answered the trainee's questions clearly and accurately.	1	2 5	3 6	4 7

6.5.5.2 Descriptive Scale

Descriptive scales do not use numbers. Instead, they divide the assessment into a series of verbal phrases to indicate levels of performance. The descriptors may vary, e.g., "Very Good" to "Very Poor," or "Strong" to "Weak." The resulting scale is deficient in that these words are open to many interpretations.

Table 16 Example of Descriptive Scale

Behavior	Performance				
	Very Poor	Poor	Average	Good	Very Good
1. The peer trainer used reflective listening skills with the trainee.	☐	☐	☐	☐	☐
2. The peer trainer answered the trainee's questions clearly and accurately.	☐	☐	☐	☐	☐

6.5.5.3 Behaviorally Anchored Scale

A behaviorally anchored numerical scale uses both words and numbers to define levels of performance. The words used are not vague value labels, but actual descriptions of behaviors that indicate the quality of the performance. The use of specific descriptions tends to make these scales more reliable than the unanchored numerical or descriptive scales.

Table 17 Example of Behaviorally Anchored Scale

Behavior	Performance	Rating
1. Peer trainer listening skills	1. Avoided looking at trainee; interrupted trainee, could not remember what trainee said.	1 2 3
	2. Some eye contact, able to repeat some of what trainee said	1 2 3
	3. Looked at trainee, responded based on statements, repeated trainee words accurately.	1 2 3

6.5.5.4 Checklists

Checklists are constructed by breaking a performance into specifics, the presence or absence of which is then “checked” by the rater. Checklists tend to be the most reliable of all rating scales because they combine descriptions of specific behaviors with a simple yes-or-no evaluation. The checklist radically reduces the degree of subjective judgment required of the rater, thus reducing the error associated with observation. While the checklist increases the reliability of the raters, a careful task analysis is required to assure the validity of the scale.

Table 18 Example of Checklist

Behavior (Statement of Objectives)	Performance	
	Yes	No
1. Peer trainer used the spec.		
2 Peer trainer stated the training with summary of the day before.		
3. Peer trainer logged the training time on system.		
4.		
5.		

6.5.6 Test Types

As you plan your test, it is important that you consider the situation for which testing is needed. The domain being tested and the skills, knowledge, and attitudes being tested will help in determining the test type you may need to use in a given learning situation.

Table 19 Test Types

Test Type	When Given	Purpose
Prerequisite Test	Prior to a course. (Enough time so that a trainee has time to un-enroll and not be charged for the class.)	To test skills that will ***not*** be covered in the course. It is assumed that all registered trainees have these prerequisite skills.
Entry Test	Prior to the class – long enough for the instructor to identify in which areas s/he may need to provide more or less instruction.	To determine at which level the various trainees are entering the class.
Diagnostic Test	At the beginning of, or during training.	Used to determine problem (or mastery) areas. Helps instructor modify instruction during the class.
Pre/Post-Test	Before training begins (Pre-test) and at the end of the training session (Post-test). Delta (Δ) between pre and post-tests indicate what impact the class had on the trainees' immediate learning.	A test of the terminal performance objective. Asks trainees to perform all sub-units directly connected to the terminal objective. (This is a level two evaluation.)
Equivalency Test	Before signing up for a training class.	To determine if a trainee needs to take a class or can bypass. Composed of items based upon the same objectives as the post-test.

6.6 Level Three Evaluations

The purpose of level three training evaluation is to determine how well the skills and knowledge taught in the class are being used on the job. This level should measure behavior change in terms of improved performance on the job. The level three needs to answer these types of questions:

1. How much of the learning were the trainees able to apply back on the job?
2. Is the amount of application acceptable? If, not, is it the content of training which is at fault?
3. How are the new skills helping to improve the technician's performance on the job?

6.6.1 Assumptions

It is assumed that trainees have demonstrated competence in a list of specified skills at the time training was completed, usually through a level two evaluation. If the level three indicates poor application of training on the job, then the cause must be identified. Common problems include:

- Problems with the provider's or supplier's course design or implementation
- Problems with the original needs analysis upon which the training was based
- Changes that have been made since the original, otherwise accurate, analysis
- The trainee is assigned to tasks unrelated to the training and is not given the opportunity to apply the training
- The wrong trainees are being sent to the training; not the target audience

In Table 20 are examples of possible reasons why a learner may not apply skills on the job satisfactorily.

Table 20 Examples of Problems

Example	Reason
• Performance objectives were not performed as stated; e.g., demonstrated instead of hands-on.	
• Practice in the course was not relevant to the real work environment.	Problem with the supplier's course design, training organization, facility, or implementation. Perhaps the real tools or equipment are not available in the training facility.
• Tests not relevant to performance objectives.	
• The skills learned are actually performed by vendors or senior personnel.	
• Tools or equipment not readily available.	Organization is not maximizing the learner's application of training on the job
• No opportunity to put new skills to use until the skill was lost or forgotten.	
• The original list of tasks was incomplete resulting in missing performance objectives.	
• The original task analysis was not based on "expert" performance.	Problem with the original analysis upon which the training program was based
• No task analysis was performed.	
Since the original analysis or request for training, there was a change in: • Supervisor • reinforcement structure • working conditions • equipment specs • fab procedures	Changes made since the original, otherwise accurate, analysis.

6.7 When to Do Level Three Evaluations

It is recommended that this follow-up take place four months to eight months after the conclusion of the training course. The length of time can vary according to the kind of training

and the content. The question that needs to be answered is: What would be a reasonable time period that would give students time to have the opportunity to use the skills and knowledge? If the period is too long, the students may not remember what was in the class.

6.8 Methods

Several methods and/or combinations of methods can be used to gather level three data. The number of participants, the location of participants and of evaluators, the type of information wanted, and other factors will influence the selection of the methods used. Surveys are most frequently used; however, follow-up interviews can provide more detail if needed. A sample survey, along with directions for using it to conduct a level three is given in Section 6.9.

6.8.1 Observations

Observations of participants can be done after they have attended training to see if tasks are being done on the job. This is a good way to validate the use of the training on the job, but it is time-consuming and uses resources organizations may not have. Some important points to remember about doing observations are as follows:

- Observers should know what to be looking for and how to interpret what they are seeing.
- Observers should be trained to conduct the observations using the same criteria.
- Observers should be as objective as possible.

6.8.2 Interviews

Interviews can be done with supervisors and trainers of participants who have attended the training. Some important points to remember about conducting interviews include the following:

- Basic questions should be developed and tried out.
- All persons doing interviews should be trained.
- Clear instructions need to be given to the person being interviewed.
- Responses should be recorded accurately or tape recorded.

6.8.3 Focus Groups

The focus group is a small group discussion conducted by an experienced facilitator and is designed to gather information and views on a particular topic or issue. Some important points to remember about conducting focus groups are as follows:

- Questions should be planned in advance.
- The group size needs to be kept small: an optimal number is between six and twelve.
- Participants should be carefully selected in order to get accurate information.
- Facilitators should be prepared.

6.9 Using the Survey for Level Three Evaluation

This section contains a sample survey, Table 21, which can be used as a template that users of supplier training can adapt for their needs. It also contains directions for using the template to collect level three data to evaluate the training provided in-house or by suppliers or other providers. This section is based on a process that has proved to be effective for the following:

- Making sure the tasks taught in the training match the responsibilities of the student/technician
- Ensuring emphasis is placed on those tasks most critical to the job
- Identifying barriers to transfer or the use of the skills on the job.

Table 21 Sample Survey Template for Varian E500

DIRECTIONS: Each of the tasks for the training are listed on the left. Check the **Yes** box if you currently perform this task on the job today. Mark the **No** box if you **do not** currently perform this task on the job. For each **No** box you checked, check the box(s) from the reasons listed to the right that describes why you are not performing that task. For each task you marked **Yes** complete the sections on frequency and difficulty.

		REASONS NOT PERFORMING TASK ON THE JOB						***COMPLETE A & B IF MARKED "YES"**	
TASKS Source Related Tasks	***Yes**	No	Task not done in my factory.	Tool has not required this task.	Have not been given the opportunity to do this task.	Task not at right level.	Others do this. (write who does task in reasons area)	**A. Frequency of performing the task.** 1=daily 2=weekly 3=monthly 4=quarterly 5=years	**B.Difficulty of performing the task** 1=very difficult 2=difficult 3=easy
1. Remove the source									
Reasons/Comments									
2. Clean the source.									
Reasons/Comments									
3. Remove extraction manipulator assembly.									
Reasons/comments									
4. Clean extraction manipulator assembly.									
Reasons/comments									
5. Reinstall extraction manipulator assembly									
Reasons/comments									

Table 21 Sample Survey Template for Varian E500 (continued)

1. The hands-on time in the training was:	☐ just right ☐ not enough ☐ too much If you marked "not enough" or "just right" please explain:_____ _____
2. To what degree did this training help you learn to do the tasks required in your job?	☐ not at all ☐ to some degree ☐ to a large degree If you marked "not at all", please state the reason(s):_____ _____
3. What suggestions, ideas, or comments do you have about the training you took?_____ _____ _____ Please return the completed survey to _____ by _____	

6.9.1 Steps in the Survey Process

There are six major steps in this evaluation process; directions follow for each step:

1. Identification of the stakeholders or individuals who have an interest in the training including the individuals who can use the results to make improvements in the training if needed
2. Compiling the list of students or trainees who attended the training in the right time frame
3. Developing the survey
4. Distribution and collection of the survey
5. Tabulation and roll-up of the results
6. Communication of the results

6.9.1.1 Identification of stakeholders

This group can include the customers or tool owners, supervisors, instructors, the developer/owner of the training and anyone who has a stake in the success of the training. It is assumed that there is a customer or sponsor of the evaluation who has a plan for using the evaluation data. If the stakeholders are not identified before the evaluation begins, it is possible to end up with data that is not used, making the evaluation process a costly activity with little result. It is not recommended that the training organization undertake an evaluation on its own. It will most likely experience resistance in asking technicians to take time away from the job to fill out surveys or participate in interviews.

6.9.1.2 Compiling the Student List

The list of students/participants who attended the supplier training in the right time frame is usually very small. A four to eight month window of time is best to allow students time to use the tasks taught in the course on the job. It is best to have at least six students who attended the training at least four months prior to receiving the survey.

6.9.1.3 Developing the Survey

The template contains basic information that is needed for equipment training except for spaces for demographic data the training user or customer may want to collect, such as name, factory, job function, certification level, etc. The fields for the tasks taught in the training need to be completed as shown in the sample survey in Table 21. Tasks that are done on the job but were not taught in the training do **not** belong on this survey. The only tasks that will go on the survey are those tasks taught in the training. There are no questions about the use of any knowledge that might have been taught in the training. Students may be using knowledge from the course in their jobs, but the survey's focus is on the actual tasks that have been transferred from the training to the job.

6.9.1.3.1 Objectives

If the course has well-written performance and enabling objectives, deriving the tasks statements for the survey template is simple. Task statements may also be taken from the performance checklists if one is used in the course. Some courses will have objectives written at a high level and some may have no objectives at all. Often there are statements about what the instructor is going to do instead of what the student will do to demonstrate competency. Instructor purpose should not be confused with student performance expected to **result** from the course. In either

case, the instructor is the best source for task statements. The instructor can provide a list of tasks the student should be able to do at the end of training.

6.9.1.3.2 Task Statements

If the survey is going to be effective, task statements must be at the right level. Too broad a statement such as “perform a quarterly PM” does not give enough detail. The student may not have been taught to do the PM the way the tool owner requires. Too much detail, “remove the cover” is unimportant and makes the survey unnecessarily long, which usually results in the survey not being filled out correctly or not being filled out at all. Task statements should be limited to one verb. The task statements for the Varian E500 survey in Table 21 were derived from the objective below.

Given an implanter and maintenance manual, the student will accomplish the following maintenance tasks in accordance with procedures contained in the maintenance manual:

Source related tasks

a. Remove the source

b. Clean the source

c. Remove, clean, and reinstall Extraction Manipulator Assembly

6.9.1.3.3 Task Statement Validation

Even if task statements can be developed with training objectives and performance checklists, the instructor should review the task statements to validate them and to look for the following.

- Inclusion of all tasks taught in the training.
- Accuracy of terms and wording used in the task statements.
- Identification of correct level, not too broad and not too specific.

6.9.1.4 Distribution and Collection

There are two basic methods of distribution and collection: electronic and personal. The higher the response rate, the more reliable the results. If twenty surveys are sent, at least ten should be collected in order to draw conclusions about the transfer of the training to the job. In addition, the smaller the number of surveys sent out, the higher the return rate should be. If six surveys are sent, all six surveys should be returned. Sometimes, both methods are used together to ensure the best response rate.

6.9.1.4.1 Electronic mail

When sending through electronic mail, the survey can be sent as a Word attachment. It is important to give clear directions on how to save the changes to the attachment and return to the designated person receiving surveys.

6.9.1.4.2 Personal delivery

Personal delivery method requires more up front planning but can get a better response rate. Hard copies can be given to identified students and then collected when completed. To get the best return rate, it is important to have a supervisor or manager set the expectation that filling out and returning surveys is a part of the training process.

6.9.1.5 Tabulation and Roll-up

The data from each survey can be entered and tallied on a blank survey as shown below. This can be used to present information to customers, equipment owners, course owners and trainers. The instructors and equipment owners or customers should pay special attention to those tasks that students marked "No." If there are several tasks marked "No," an analysis needs to be done to see if the content of the course needs to be changed or if the problem lies with the lack of priority placed on allowing the technician time to practice skills after returning from the course.

Tasks Source-related tasks	Yes	No	Task not done in my factory	Tool has not required this task.	Have not been given the opportunity to do this task.	Task not at the right level.	Others do this. (write who does this)	**Frequency of doing the task.** 1=daily 2=weekly 3=monthly 4=quarterly 5=yearly	**Difficulty of the task** 1=very difficult 2=difficult 3=easy
1. Remove the source	5	2		2				5 reported monthly	5 reported easy

6.9.1.5.1 Possible Interpretations

The tool owner or supervisor should interpret the results and determine if the reasons given for not performing the task indicate a problem with the training content.

- "Task not done in my factory" may identify tasks that should not be taught in customized training but may be appropriate in classes at the supplier site (as long as there are not too many of these).
- "Tool has not required task" may mean the tool has either not broken or task was done on another shift.
- "Have not been given the opportunity to do this task" could mean the tech's supervisor has assigned the tech other work instead of making the opportunity for application a priority.
- "Task not at right level " could mean the tech's certification level is higher or lower than the task; could be a flag that the tech is not being sent to the right class.
- "Others do this" can identify when a senior tech or supplier tech does this task.

6.9.1.5.2 Frequency and Difficulty

The data on frequency and difficulty should not be included in the survey, unless it is data the customer or tool owner plans to use. The customer needs to decide how to maximize the supplier instructor expertise and balance that against opportunities for training tasks on the factory floor. The customer may ask that major concentration be placed on tasks that are performed frequently and are difficult as opposed to tasks that are infrequent and difficult, the theory being that class time would be wasted if the tech never needs to do this task or by the time he does, he can't remember what he learned. It might be more cost-effective to teach easy tasks that are done frequently on the floor because there is ample opportunity for hands-on practice.

6.9.1.5.3 Calculating a Transfer Rate

A transfer rate can be calculated to determine numerically the percent the training was used on the job. If there are at least six respondents who currently do the tasks on the job, a transfer rate can be calculated. The transfer rate represents the percent of tasks that the respondents are using

on the job over an identified standard. The standard may vary, depending on the purpose of the training, the provider of the training, etc., but it is important to set a minimum standard for transfer. This is done by asking the question about each task or skill, “Out of the ten techs who attended this training, what number could I reasonably expect to be using this skill?” At a supplier class, where the training is somewhat generic, the answer may be seven out of ten or even lower. If the training is customized, then the answer may be eight out of ten (80%) or nine out of ten (90%).

The transfer rate is calculated by using the following procedure:

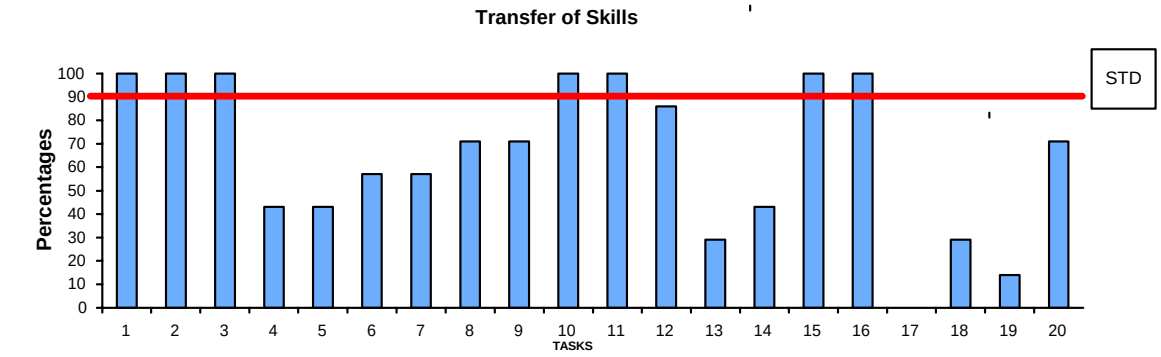
1. For each task, calculate the percent of respondents using the task on the job.
2. Count the number of those tasks that have a percent that meets or exceeds the standard.
3. Divide this number by the total number of tasks.
4. This percent is the transfer rate.
5. If this percent meets or exceeds the standard, the transfer meets the standard for transfer.

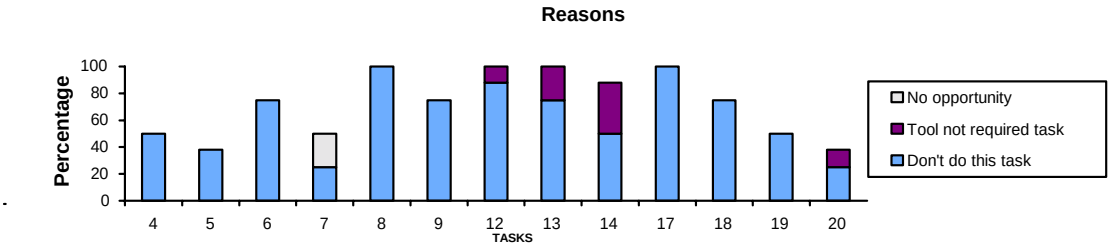
6.9.1.6 Communication of the Results

Using an Excel graph is a good way to present the results of the evaluation because it is easy to see if the training met the standard for transfer and to identify problem areas. Figure 7 provides an example.

FAB XXX **40 HOUR CLASS** **CMVXXX**

# of Participants	7
# of Skills Evaluated	20
Transfer rate = % of tasks meeting standard of 90%	**35%**





SKILLS:

1. Access Scv. Software Commands.
2. Move Wafer Stage.
3. ID Status of Sub-sys.
4. ID EEPROM Version
5. ID Main Software Version
6. Exp. Shutter Open Time Meas.
7. Waf. Orient Flat Detect Capab.
8. Reset Wafer & Ret. Stage functs.
9. Check/Reset vaccuum solenoids
10. Check Lamp Unif.
11. Check Waf. Flatness
12. Adj. Waf. Loader motor speeds.
13. Adj. Waf. Ldr. turn table encoder pulses.
14. Adj./Cal. Orient Flat Detec. signals
15. ID Lamp power in normal and flash
16. Cal./Adj Exp. Integrator stability
17. Verify proper VCO oper.
18. Ts Ret. Stage probs.
19. Chk./Adj. Y-stage interf. mir. to X-stage travel parall.
20. Perf. Stage Running Serv. Software

Figure 7 Sample of Transfer Chart

6.9.2 Level Three Summary

Key Question: How much of the learning is being applied on the job?

Timing	Useful to Whom	Measurement Tool(s)	Responsibility for Measurement Design	Recommendation in Brief
Four months after the course conclusion.	Both *Supplier* and *User Supervisor:* to discover if the course-certified skills are being utilized on the job or not; if not, additional performance analysis is indicated.	• Follow-up survey (trainee) • Follow-up interview form (trainee) • Follow-up survey (supervisor) [See example in Appendix C] • Follow-up interview form (supervisor)	*Supplier*: Implementation of regular surveys and initiation of occasional interviewing to follow-up *standard* course training; Drafting of specialized follow-up instruments in *custom* training *User*: Cooperation and assistance with regular follow-up; Initiation of advanced planning for special follow-up evaluation of custom training.	Supplier should, for standard courses, use existing models and research to create and use survey and interview techniques which gather follow-up data from trainees and their supervisors of post-training job performance. User should assist and cooperate with completion of routine follow-up surveys. User and supplier should, for custom training, jointly plan in advance any special follow-up evaluation of on the job use of skills.

6.10 Level Four Evaluations

Level four evaluations answer the question, “What return did the training investment yield?” Cost benefit analysis is the method for measuring results. This level measures results in terms of organizational improvement. Results can include cost savings, work output improvement, and quality changes. This involves collecting data before and after training and analyzing the improvement. Most models involve assigning a dollar value to data. For example, if a value can be assigned to increased output, cost savings, time savings, scrap, rework, etc., then the savings can be divided by the training investment to provide the return on investment (ROI). Every effort must be made to isolate the variables that caused the improvement. *Evaluators must be careful not to suggest that all improvement resulted from the training unless it can be proved.*

The key to the cost analysis is determining what costs to include. If the evaluation is to determine the worth of an in-house developed training program, all costs, developing the training, holding the training, attendance at the training, must then be compared with the benefits of the program to decide whether the program’s benefits are worth its cost, and if required, to demonstrate the program’s ROI.

6.10.1 Definitions

Level four evaluations require the use of the cost analysis; the costs of a training intervention are compared with the benefits or with the expected results. The table below provides definitions of the tools used in level four evaluations.

Tool	Description	Usage
Cost Benefit Analysis	Both costs and benefits are computed in dollars.	Comparison of the cost of a training or other intervention with the benefits that result from it to see if the benefits outweigh the costs. Can help decide whether to continue a program.
Cost Effectiveness Analysis	Only the costs are computed in dollars; the results are assessed by how many of the program's objectives were achieved.	Works best when the benefits are hard to attach a monetary value to. Could decide which of two training courses was most effective by collecting before-data (such as number of errors) and after-data, and comparing the two programs to see which was more effective in reducing errors.
Cost Savings Benefits	Reduction in current costs or replacement of current costs that are expected to rise with increase costs	Analyze and calculate costs for before- and after-data to show how a training program resulted in a 50% reduction of spares totaling 10K for the quarter.

6.10.2 Calculating Costs

The first step is deciding what costs to include; after that, there are numerous models to follow. A frequently used model is the one developed by the American Society for Training and Development (ASTD). It specifies what should be included as costs, such as the following.

1. *Personnel costs* are the salaries and wages, including lost production, involved in the design, development, and the delivery of the training program.
2. *Training materials* can include development and delivery of expendable training materials (handouts, flip charts, etc.) and non-expendable materials (reusable slides, manuals, etc.).
3. *Delivery costs,* if included, consist of wages and salaries of instructors and, if applicable, of students, travel expenses, and facilities.

The total cost of the project is the total labor or loaded labor costs plus the total direct costs (expenses).

Cost Category	Calculation	Cost Totals
Direct labor: salary or wages divided by days worked per year (average is 230) = cost per day	Cost per day for individual involved multiplied by number of days or hours spent on project	Direct Labor Costs
Fully loaded labor: salary or wages plus fringes (40%) of salary plus overhead (125% of salary divided by days worked (average is 260). = cost per day or use	Same calculation as above. Since fully loaded labor is usually three times direct labor; a labor multiplier of three can be used. Example: direct labor cost per day times three.	Loaded Labor Costs
Direct expenses: materials, travel, etc.	Calculate for each person and multiply for number of units.	Direct Costs

6.10.3 Impact versus ROI

It is not always worth the effort to try to calculate benefits in dollars. For example, a customized lecture and hands-on class was developed to address a problem with implanter downtime resulting from many new operators on the floor. The six months following the training showed that source life had increased 50% and machine efficiency 15%.

An ROI could be demonstrated easily figuring the costs of development time, 360 hours (60 hours for every hour of instruction) divided by the decrease in equipment downtime. Going to this effort may not seem worth the time because the training class obviously accomplished its goal and the impact was obvious.

6.10.4 Feasibility of Doing a Cost Benefit Analysis

A level four can be very complex and time consuming and is usually undertaken only if there is a stated need or request and a definite plan for using the data. How complex it becomes and how much detail it involves most likely will depend on what decisions are expected to result from it. The impact of the decisions needs to outweigh the cost of doing the evaluation. Below are some situations that might call for reporting results of a training program in terms of positive impact to the organization instead of trying to do a cost/benefit analysis.

- Costs can be expressed in dollars, but benefits are subjective and difficult to quantify and convert to dollars.
- Data needed is not kept on a regular basis or is difficult and time consuming to extract, thus adding to the cost of doing the evaluation.
- Data regarding equipment or technician performance related to equipment may be available in a report or system but is unreliable because of inconsistent procedures in recording data. Example: data to figure MTBF is seldom consistently recorded.
- The training program has become institutionalized, considered part of the employee's education and is considered as an employee benefit.
- There are so many variables (both trained and untrained techs working on same tool) it would be impossible to pull out the impact of the training class.

6.10.5 Summary of Level Four

Key Question: What return did the training investment yield?

Timing	Useful to Whom	Measurement Tool(s)	Responsibility for Measurement Design	Recommendation in Brief
User dependent.	*User:* for verifying that training dollars were well spent and that program goals were achieved. *Supplier:* for demonstrating that training contributes to overall business results.	Collection of data (with appreciation for conflicting variables in a non-controlled study) such as: • MTTR • Equip't uptime • Wafers broken • # of product defects • # of equip't-related safety violations • ROI	User and supplier, jointly	User and supplier should develop a mutually agreeable model for measuring results as part of the "training contract." There should be a plan for using the data.

7 INSTRUCTOR CERTIFICATION

7.1 Goal

Provide a system for TPIC member companies to qualify and monitor personnel who are assigned as training course instructors.

7.2 Introduction

To help meet customer requirements and guide supplier training programs, TPIC has implemented a system for qualifying and certifying instructors to teach courses. The course owner (supplier) is responsible for the quality and effectiveness of classes taught. This section contains evaluation tools to be used by the course owner/mentor and by the instructor.

7.3 Roles and Responsibilities

Evaluators and instructors enter into this certification program as a partnership.

The supplier is responsible for ensuring that the instructor qualifies and maintains the necessary skills required to effectively deliver a technical training class.

The supplier is also responsible for maintaining the documentation associated with instructor certification.

7.4 Certification Process

7.4.1 Pre-Certification

1. The course evaluator and prospective instructor candidates should read this document, *International SEMATECH Instructor Certification Guidelines*. The document is available on the Internet at www.tpic.org.
2. The course evaluator and candidate identify the relevant skills and knowledge areas needed to deliver a specific class.
3. The course evaluator and candidate work together to draft a personalized instructor Development Plan.
4. In this process, both determine if the skills are met, and for those not met, identify ways to improve proficiency in that skill. The Development Plan is a "living document" to set goals for professional improvement development and to track improvements and changes.
5. The candidate works toward completing his/her Development Plan.
6. The course evaluator reviews the performance of the candidate against the Development Plan and then updates the Plan as needed.

7.4.2 Certification Process

The following list outlines the recommended steps in the instructor certification process:

1. The instructor attends the course in a student role, participating in all class/lab activities.
2. The instructor attends the course a second time with the *Course Instructor Guide*, and observes the course being taught by a certified instructor.
3. After at least two weeks of preparation time, the instructor and course owner/mentor set up a team teaching class.
4. The instructor will teach to the course owner/mentor until the course owner/mentor determines that the instructor is competent to teach the course alone. Course owner will use the TPIC Instructor Certification Checklist (refer to Section 7.8 and 7.9).
5. Once the course owner/mentor determines the instructor is competent to teach the course, the instructor is assigned a course session for certification.
6. The course owner/mentor attends the course session and evaluates the instructor per TPIC guidelines using the Instructor Certification Checklist.
7. After the completion of each evaluation, the course owner/mentor sets up a follow-up meeting with the instructor to review the outcome of the certification evaluation.
    - If the course owner/mentor certifies the instructor, the follow-up meeting consists of reviewing the instructor certification checklist, the course owner/mentor's recommendations and the evaluation of the instructor.
8. Any action item will be documented and a method is established to track closure of action items. If the course owner/mentor declines to certify, the follow-up meeting consists of reviewing the instructor certification checklist and identifying areas that need improvement. A skills improvement plan is then mutually developed and a certification or recertification class is scheduled.

9. After initial certification, re-evaluation of the instructor should be performed annually.

NOTE: O*ther indicators or events that may require evaluation/recertification more often include Level 1, 2, 3, or 4 evaluation results; major tool/equipment modification; software revisions; or revision of the class.*

7.5 Monitoring Classes

7.5.1 Introduction

Each class should be monitored by the supplier's course owner or assigned mentor. This is done by reviewing and tracking the Level One evaluations (Student Critiques) and Level Two evaluations (including Pre-Post test). Levels Three and Four evaluation results may be helpful if such tools are available.

7.5.2 Student Critique (Level One Evaluation) Results

1. After every class, the course owner/mentor reviews the scores and comments for student satisfaction from the completed Level One evaluation forms.
   (Refer to Section 6 for a sample of TPIC Course Evaluation Forms.)
2. If the critique scores fall below a recommended average, or a low trend develops, the course owner/mentor follows up with the instructor to determine what problems may exist.

NOTE: *Problems leading to low student satisfaction may be due to the course design, course administration, course materials, inappropriate target audience, training tools or other related factors, and not necessarily the instructor. It is important for both parties to be aware of all possible contributors to the outcomes of course evaluations.*

3. If it appears that there are problems associated with the instructor's performance, the course owner/mentor can recommend an audit. However, the training manager should be the decision maker on whether or not to conduct an audit.
4. If problems associated with the instructor's performance persist, the instructor may be de-certified upon the approval of the training manager. A corrective or remedial action plan should be arranged, executed, and managed by the training manager.

7.5.3 Class Effectiveness (Level Two Evaluation Results)

1. After every class, the course owner and the instructor reviews the students' test scores and completion checklist. This review should indicate that each student has acquired the intended skills taught in the course.
2. If fewer than 80% pass a given class, or a substandard trend develops, the course owner/mentor follows up with the instructor to determine what problems may exist.

NOTE: *Problems leading to low student performance may be due to the course design, course administration, the course materials, inappropriate target audience, training tools or other related factors, and not necessarily the instructor. It is important for both parties to carefully analyze evaluation data to determine the possible roots of probable faults.*

3. If it appears that there are problems associated with the instructor's performance, the course owner/mentor can recommend an audit. However the training manager should be the decision maker on whether or not to conduct an audit.

4. If problems associated with the instructor's performance persist, the instructor may be de-certified upon the approval of the training manager. A corrective or remedial action plan should be arranged, executed, and managed by the training manager.

7.6 Instructions for Auditing and Follow-up

7.6.1 Introduction

Auditing the instructor is an ongoing process in the delivery of quality instruction. The directions listed below are provided to assist the instructor and auditor in improving the quality of training. The relationship between instructor and auditor must be of a cooperative nature with a common goal of maximizing instructional effectiveness.

7.6.2 Procedure

The auditor and instructor will read and review these instructions and the instructor certification checklist and definitions.

The auditor will:

1. Use the checklist and mark accordingly with the understanding that different instructors use different teaching techniques and styles. If any item is marked 'unsatisfactory,' the remarks section must be filled out with an explanation.
2. Arrive before class starts and arrange with the instructor for a suitable place in the room for the auditor that will not create a distraction.
3. Stay for at least one instructional period as defined by the course auditor and instructor, refrain from participating in class and avoid being conspicuous to the students.
4. List instructional strong points.
5. List suggestions for improvement.
6. Monitor and document student reaction to the instructor during class. Look for verbal, facial, and body language reactions (positive and negative) from students.
7. Provide a statement regarding safety coverage and procedures within the course.
8. Conduct an audit review meeting with the instructor as soon as possible after the evaluation. The audit review meeting should consist of reviewing the audit checklist and must include strong points and areas for improvement.

7.7 Instructor Certification Flow Chart

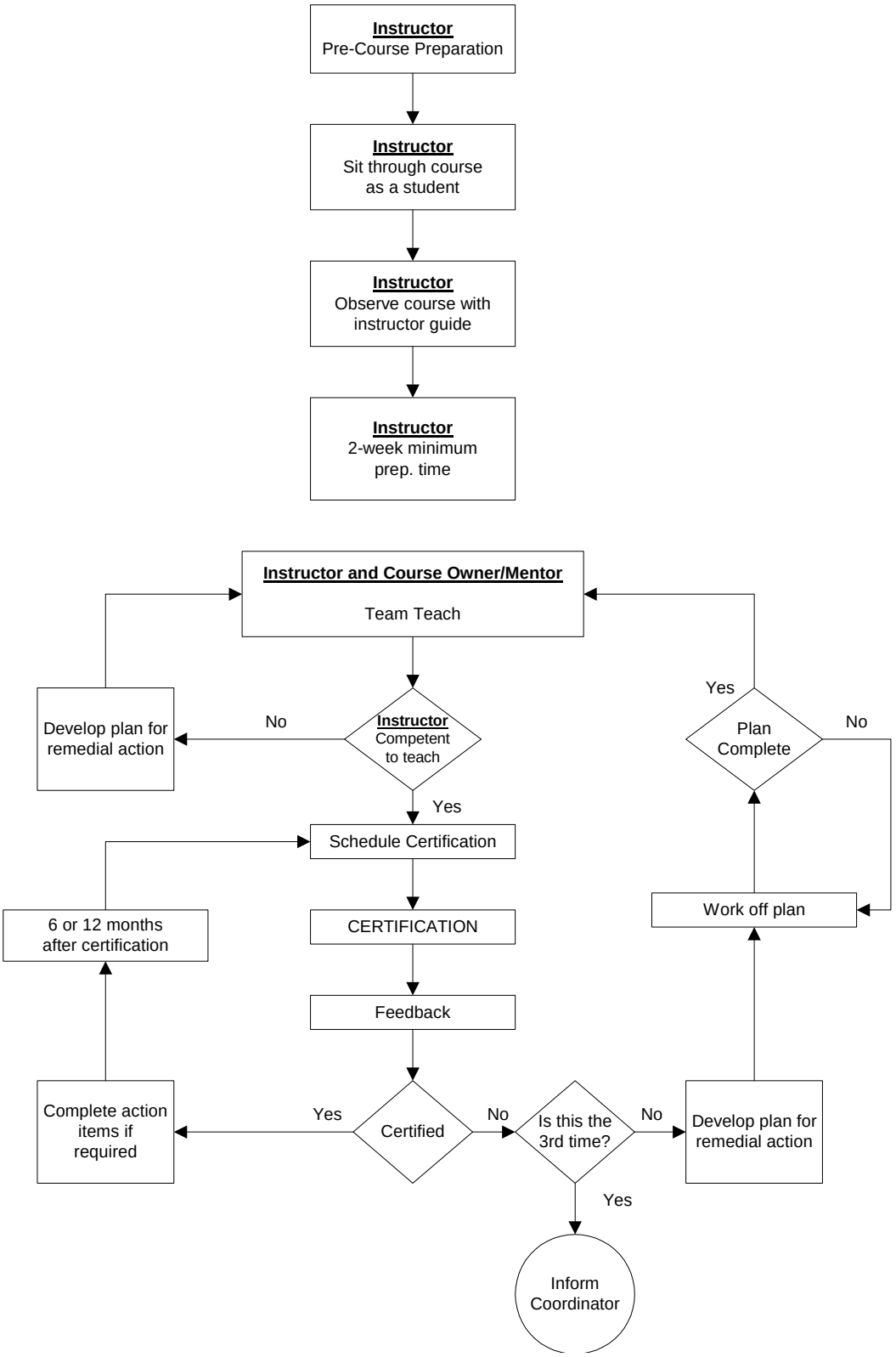


Figure 8 Instructor Certification Flow Chart

7.8 Instructor Certification Checklist

Instructor: _____ **Date:** _____

Course Auditor: _____ **Class**: _____

E=Excellent S=Satisfactory U=Unsatisfactory N/A=Not Applicable

Item	E	S	U	N/A	REMARKS
Pre-Checks					
Instructor Guide					
Current					
Personalized					
Conditions					
Training Aids					
Classroom					
Logistics					
Other					
Classroom Presentation					
Explains Class Rules					
Explains Objectives					
Establishes Professional Rapport					
Uses Open-Ended Questions					
Maintains Class Control					
Encourages Student Participation					
Encourages Class/Instructor interaction					
Assesses student progress					
Clarifies/Amplifies important points					
Uses examples and analogies					
Demonstrates Organization and Preparation					
Transitions between topics					
Teaches to objectives					
Reviews/Summarizes Key Points					
Emphasizes Safety					
Other					
Other					

Item In the lab, practices:	E	S	U	N/A	REMARKS
Safety Procedures					
Mechanical Skills					
Electronic Skills					
Computer Skills					
Proper Procedures					
Maintain Class Control					
Coaching Skills					
Tool Knowledge					
Troubleshooting Ability					
Resourcefulness					
Other					
Other					
Instructor Traits					
Training Aid Technique					
Delivery Rate					
Use of Voice Inflection					
Use of Movement					
Content Expertise					
Use of Eye Contact					
Clear Understandable Speech					
Distracters Not Used					
Professional Appearance					
Use of Listening skills					
Teaching to Objectives					
Positive Role Model					
Other					
Other					
Other					
Course Admin.					
Database Updates					
Student Evaluations					
Student Certificates					
Cleanup for next class					
Course Critique Eval.					
Customer Interface					
Other					

7.9 Instructor Certification Checklist Definitions

7.9.1 Pre Checks

Current:	Does the instructor have the most current copy of related documentation? (Lesson Plans, Manual, Student Handouts)?
Personalized	Has the instructor made notes or customized the instructor guide?

7.9.2 Conditions

Training Aids	Are the training aids in good working order?
Classroom	Is the classroom clean and organized? Are there enough chairs and tables etc.?
Logistics	Have other important support services and materials been requested, scheduled, and/or provided?

7.9.3 Presentation

Explains Class Rules	Did the instructor explain the class rules, safety and emergency procedures?
Explains Objectives	Were they given to the student and does the instructor go over these with the student?
Establishes Professional Rapport	Does the instructor present a positive attitude, and enthusiasm for the class? Does the instructor dress accordingly and act as a role model?
Uses Open-Ended Questions	Does the instructor question students with pertinent open-ended questions that lead to answers, instead of “give away” questions or questions the instructor answers?
Maintains Class Control	Does the instructor maintain control of the class during all activities?
Encourages student Participation	Does the instructor encourage students to be an active part in the class? Does the instructor provide positive feedback to acknowledge their participation?
Encourages Class/Instructor Interaction	Does the instructor encourage positive feedback from the students to each other and the instructor?
Assesses student progress	Does the instructor check each student (can use quizzes, questions or actual performance) to make sure they are keeping up with the class?
Clarifies/Amplifies Important Points	Are the important points and topics discussed?
Uses examples and analogies	Does the instructor use analogies that are clear and understandable?
Demonstrates Organization and Preparation	Is the instructor organized and prepared for each class day and class section?
Transitions between topics	Does the instructor transition to different topics smoothly and evenly and not continually revisit past topics?
Teaches to objectives	Does the instructor ensure the students achieve the course objectives?
Reviews/Summarizes Key Points	Does the instructor summarize and review material and solicit questions/clarifications on topics?
Emphasizes Safety	Does the instructor discuss safety issues for the system?

7.9.4 In the lab, instructor practices:

Safety Procedures	Does the instructor follow, and have the students follow the safety guidelines for the course/tool?
Mechanical Skills	Does the instructor use the established mechanical techniques, tools, and procedures?
Electronic Skills	Are the established electronic procedures, test equipment, and techniques used?
Computer Skills	Are the established computer procedures and techniques used?
Proper Procedures	Does the instructor use and have the students use defined and established procedures for the equipment?
Maintain Class Control	Are the students in the proper area? Does the instructor encourage students to participate in the lab tasks?
Coaching Skills	Does the instructor coach students through procedures rather than doing them?
Tool Knowledge	Does the instructor have the depth and scope of machine and process knowledge to answer student questions?
Troubleshooting Ability	How well does the instructor lead the class and/or handle unscheduled machine problems?
Resourcefulness	How well does the instructor adapt to problems, unscheduled interruptions, and student personalities/abilities?

7.9.5 Instructor Traits

Training Aid Techniques	Are training aids used properly and effectively?
Delivery Rate	Does the instructor speak at an effective rate for the class to follow?
Use of voice inflection	Is the instructor monotone or too loud?
Use of movement	Does the instructor's movement assist in maintaining student's attention?
Content Expertise	Does the instructor's subject matter knowledge invoke confidence in the students?
Use of Eye Contact	Does the instructor look at students during lecture and make eye contact when answering questions?
Clear Understandable Speech	Can the instructor be clearly heard? Does the instructor speak to the students rather than the wall, board or projector?
Distracters Not Used	Does the instructor have traits or habits that distract attention, like clicking markers, pacing, jingling coins? Does the instructor use inappropriate speech. (slang, profanity)? Does the instructor overly use verbal connectors (um, ah, OK, Right)?
Professional Appearance	Does the instructor dress and act in a appropriate manner for the occasion?
Use of Listening Skills	Does the instructor practice good listening skills?
Teaching to Objectives	Does the instructor keep to the stated course objectives?
Positive Role Model	Does the instructor conduct the class with uncompromising integrity and professionalism?

7.9.6 Course Administration

Database updates	Does the instructor update the database in a timely manner?
Student Evaluations	Does the instructor process student testing and/or course completion results in a timely manner?
Student Certificates	Does the instructor complete student certificates in a timely manner?
Cleanup for next class	Does the instructor ensure the classroom/lab is clean and the equipment is in good working order?
Course Critique Evaluation	Does the instructor review the critiques and enter them in the database?
Customer Interface	Does the instructor: listen to the customer, provide a friendly and helpful attitude when responding to the customer's needs, and communicate mutual intentions and expectations?

7.10 Definitions

Audit	The process of sitting in a class and observing the instruction. Its purpose is to determine if the course objectives are being taught and that the students are learning.
Auditor	A person tasked with reviewing and auditing the instructor's performance and skills while teaching a class. This is normally done after a person is certified to teach that class.
Candidate	A person who is aspiring to teach the class
Certification	Stating that the instructor can teach this class with satisfactory results. This is based on the instructor's general and equipment specific knowledge, teaching ability, and having demonstrated a successful class delivery.
Instructor Guide	The documentation that guides the instructor in teaching the course. The Instructor Guide should contain notes, class schedule, and references to class materials.
Course Owner	The supplier is the ultimate owner and accountable for the course. Typically, the assigned course owner may be the person who produced the course or is currently designated by the supplier company as the owner.
Co-teach	When two or more instructors teach the class, either by taking turns teaching the entire class, or dividing the class into groups, one for each instructor (see also "team-teach").
Deliver	The process of presenting the course
Evaluator	A person tasked with reviewing and auditing a candidate's performance and skills while teaching a class for certification
Certified Instructor	A person who has been certified by the equipment supplier/class owner to have the demonstrated knowledge, skills and abilities to successfully teach this class
Mentor	An experienced instructor or knowledgeable person who helps and guides the candidate to obtain the skills and knowledge needed to teach a class
SEMATECH Instructor Certification Guidelines	Guidelines provided by equipment suppliers and their customers for instructor certification. These documents are available on the Internet at the TPIC website, www.tpic.org.
Personal Development Plan	A written record of actions for identified areas that will help the candidate or instructor to improve upon his/her teaching of the class. The Development Plan is a 'living document' to set goals for professional improvement development and to track improvements and changes.
Team teach	When two or more instructors teach the class, either by taking turns teaching the entire class, or dividing the class into groups, one for each instructor (see also "co-teach")

8 PLANNING FORMS FOR TRAINING PROJECTS

8.1 Introduction

As covered in the first section of this document, the ISD training project steps include the following:

- Identify Needs
- Analyze Needs
- Design Course
- Develop Course Materials
- Pilot Course
- Implement Course
- Evaluate Course

Each of the steps should be planned and tracked.

Spreadsheet or word processing software can be used to generate a wide range of forms that can be used to plan and track the progress of training project activities. Following are some examples of forms that have been used in the execution of equipment specific training projects in the semiconductor industry.

- Design Document
- Team Charter
- Team Member Roles and Responsibilities Chart
- Project Planning Chart
- The Course Map or Skills Hierarchy
- Materials Development Tracking Chart

8.2 Design Document

The design document is a summary of the front-end analysis completed to date, including strategies for organizing, delivering, and evaluating the course. It is used to communicate the course plan to management and product principals. It gives a detailed overview of the course and its intent, and documents the development process to date. It is a description of the proposed course design.

The design document may have a sign-off sheet to validate that management and product principals have reviewed, and approved, the course design. Signature approvals may be requested from such principals as:

- Course Owner
- Subject Matter Expert
- Training Manager
- Customer
- Instructional Designer
- Product Development Manager

The course owner has overall responsibility for the content of the design document and of the course.

(Course Name) Design Document	
Course Owner: Enter the Course Owner's name	**Course & Course Number:** Enter the complete course name and number.
Training Location: Describe the typical delivery location.	**Length of Course:** Enter the length of the course in days.
Performance Goal: Brief statement of the performance deficiency to be corrected through training (the intended outcomes).	
Target Audience: Enter the target audience description.	
Number of Persons to be Trained:	
Course Objectives: Enter the terminal objectives that define the scope of the course.	
Student Prerequisite Skills: Enter the prerequisite skills required for success in the course. Include any prerequisite courses required for successful completion of this course.	
Performance Test: Identify the outcome by which you will determine that the course objectives have been met.	
Subject Matter Expert(s): Identify the subject matter experts who will validate the course content.	
Training Aids and Materials List presentation aids or student materials that will be used to deliver the course.	**Tools and Materials for Practice** List equipment, loadlocks, systems, calibration tools that the students will need to perform the hands-on exercises.
Practice Exercises Practice exercises consist of two phases: (1) completion of written practice exercises, and (2) hands-on exercises where students will be required to disassemble a process chamber and reassemble it correctly. Students will be required to complete both exercises repeating any areas they miss until they achieve 100 percent correct.	
Training Conditions/Environment: Summarize the conditions and environment where the practice will take place.	
Approvals Required:	
Target Pilot Date:	

Figure 9 Sample of Course Design Document

8.3 Team Charter

When the course development project has multiple contributors, it is useful to define the scope and purpose of the development team.

A Team Charter, like the one below, can define the scope of the team, and can be used to report to management the team's overall responsibilities.

Westech Polisher PBET

Team Sponsor	• Shift Operations Facilitators for C and D shifts			
Background	• The Westech development team met with training coordinators requesting assistance in the organization and delivery of a Westech Polisher PBET class. The team was tasked with creating a class which had available only sparse written materials, and had only a couple of weeks in which to prepare for delivering the pilot class.			
Objectives	• Deliver Westech PBET Pilot in Q2 (actual 1/17–2/21 – Team members were not very satisfied with the results.) • Meet once a week for 3–4 hours to strategize lessons. • Revise Westech PBET using lesson planning approach, plan for seven class sessions, produce some supporting videos, and deliver new class (done 5/22–7/10 --Results were extremely favorable.) • While in the process of revising the Westech PBET, the team will attempt to co-develop SpeedFAM lesson plans wherever possible. • Make final revisions to the Westech course materials and turn over to second delivery team in late August. • Deliver third Westech PBET class using final version of training materials in late August time frame.			
Leader	• Charles	Maint. Tech		D shift
Members	• Jeff	Wafer Fab Tech	A shift	
	• Mark	Wafer Fab Tech	D shift	
	• Zelma	Trng Coor.		C/D split
	• Julian	Trng Coor.		E shift
Resources	• Peter	Process Eng.		E shift
	• John	Maint. Tech		A shift
Other Needs	• More MT's are needed to backfill polish area for other MT's who may be involved in PBET development and/or delivery activities.			

Figure 10 Sample of Team Charter

8.3.1 Team Member Roles and Responsibilities Chart

Figure 11 shows an example of a form that can be used to list which team members would be involved in the execution of specific training project activities.

The form is divided vertically by each of the eight phases of the PBET ISD process. Each phase is further subdivided into specific substeps of activities. The names, titles, phone numbers and other pertinent information for team members are listed horizontally.

The letter "X" indicates the activities that each member has been assigned, based on an individual's role, experience, and availability.

Phase	Activity	Team Members								
		Joe Leader	James Tech	Tracy Engineer	Bill Tech	Laura Developer	Julian Developer	Paul SME	Mike SME	Craig Manager
Identify	Mission Statement	X	X	X	X	X	X			
	Team Members	X	X	X	X	X	X	?	?	
	Resources									
	Roles and Responsibilities									
	Equipment/Materials									
	Procedures									
	Intended Outcomes	X	X	X	X	X	X	X	X	
	Develop Design Document									
	Instructors (train-the-trainers)									
	Approval			X					X	X
Analyze	Job & tasks to be performed by WFTs	Analyst	Analyst	Expert Performer	Performer & Analyst	Analyst	Analyst			
	Skills & Knowledge	X	X	X	X			X	X	
	Performance Objectives	X	X	X	X	X	X			
	Skills Hierarchy	X	X	X	X	X	X			
	Instructional Strategies	X	X	X	X	X	X			
	Existing Materials	X	X	X	X	X	X			
	Approval								X	X
Design	Develop Skill Tests	X	X	X	X	X	X			
	Lesson Plans	X	X	X	X	X	X			
	Approval	X	X	X	X	X	X		X	
Develop	EST Materials: participant (manual, foils, instructor guide)	Writer	Writer	Reviewer	Writer	Reviewer	Reviewer	Writer		
	Approval	X	X	X	X	X	X	X		
Pilot	Schedule Pilot Class	X								
	Identify Instructors and Students	X								X
	First Test of EST Course	X	X		X	X	X			
	Review and Revise	X	X		X	X	X			
Deliver	Schedule EST Class(es)	X				X				X
	Conduct Class(es)	X	X		X	X				
Evaluate	Implement level 1 Eval.	X	X		X	X	X			
	Review Results of Eval.	X	X	X	X	X	X			X

Figure 11 Team Member Roles and Responsibilities Chart

8.3.2 Project Planning Chart

The Gantt chart (After Henry Laurence Gantt, 1861–1919) has been and continues to be one of the most widely used project planning tools. The next figure illustrates an example of how a training development team can plan and track its progress toward the completion of individual phases of the ISD process. The first two columns of this project planning form are duplicates of

the information that was used to create the Roles and Responsibilities Chart in the preceding figure.

The major difference between this chart and the preceding one is that this one is used to plan in advance by estimating when specific activities will begin and when they will be completed. The theoretical estimated time to start and complete a specific activity is shown shaded on the spreadsheet. The actual start time is depicted by the left hand arrow while the right hand arrow shows when an activity has been completed. The dashes between arrows indicate the time elapsed between the start and completion of a single task.

The time scale can be in weeks, days or months depending on the complexity of the training project. The Gantt chart also makes an excellent presentation format for project review meetings. It is easy for attendees to see, at a glance, the status of the project and performance towards the planned goals.

Phase	Activity	Time Table in Work Weeks																			
		W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26
Identify	Mission Statement	↔																			
	Team Members	←	→																		
	Resources	←	→																		
	Roles and Responsibilities	←	→																		
	Equipment/Materials	←	→																		
	Procedures	←	—	→																	
	Intended Outcomes	←	—	→																	
	Instructors (train-the-trainers)	←	—	—	—																
	Approval																				
Analyze	Job & tasks to be performed by WFTs																				
	Skills & Knowledge		←	—	—																
	Identify Performance Objectives		←	—	→																
	Write Performance Objectives																				
	Skills Hierarchy		←	—	→																
	Instructional Strategies																				
	Existing Materials	←	—	—	—																
	Approval																				
Design	Develop Skill Tests																				
	Lesson Plans																				
	Approval																				
Develop	EST Materials: participant (manual, foils, instructor guide)																				
	Approval																				
Pilot	Schedule Pilot Class																				
	Identify Instructors and Students																				
	First Test of EST Course																				
	Review and Revise																				
Deliver	Schedule EST Class(es)																				
	Conduct Class(es)																				
Evaluate	Implement level 1 Eval.																				
	Review Results of Eval.																				
Revise	Review and Revise EST Course as Needed																				
			Estimated time needed for task completion																		
	LEGEND:	←	Actual start date																		
		→	Actual completion date																		

Figure 12 Project Planning (Gantt) Chart

8.3.3 The Course Map or Skills Hierarchy

Following the completion of the job and task analysis steps of the ISD process, training developers identify performance objectives. These are the course objectives that will become the essential building blocks of skills and knowledge for the training course. The relationship and sequencing of these performance objectives can be displayed by using a course map or skills hierarchy. Figure 13 shows an example of a course map for a generic operations training class. The rectangles contain the titles of individual performance objectives. Progression through the course map is from the bottom up—that is, from the lowest skill to the highest. The numbered circles indicate specific branches within the course map that could be assigned to individual developers within a development team.

For more details on the use of course maps and how to develop them, refer to section AN-3 of the *SEMATECH Performance Based Equipment Training Participant Guide* (Technology Transfer #95102995A-TRG). These documents are available on the Internet at the TPIC website, www.tpic.org.

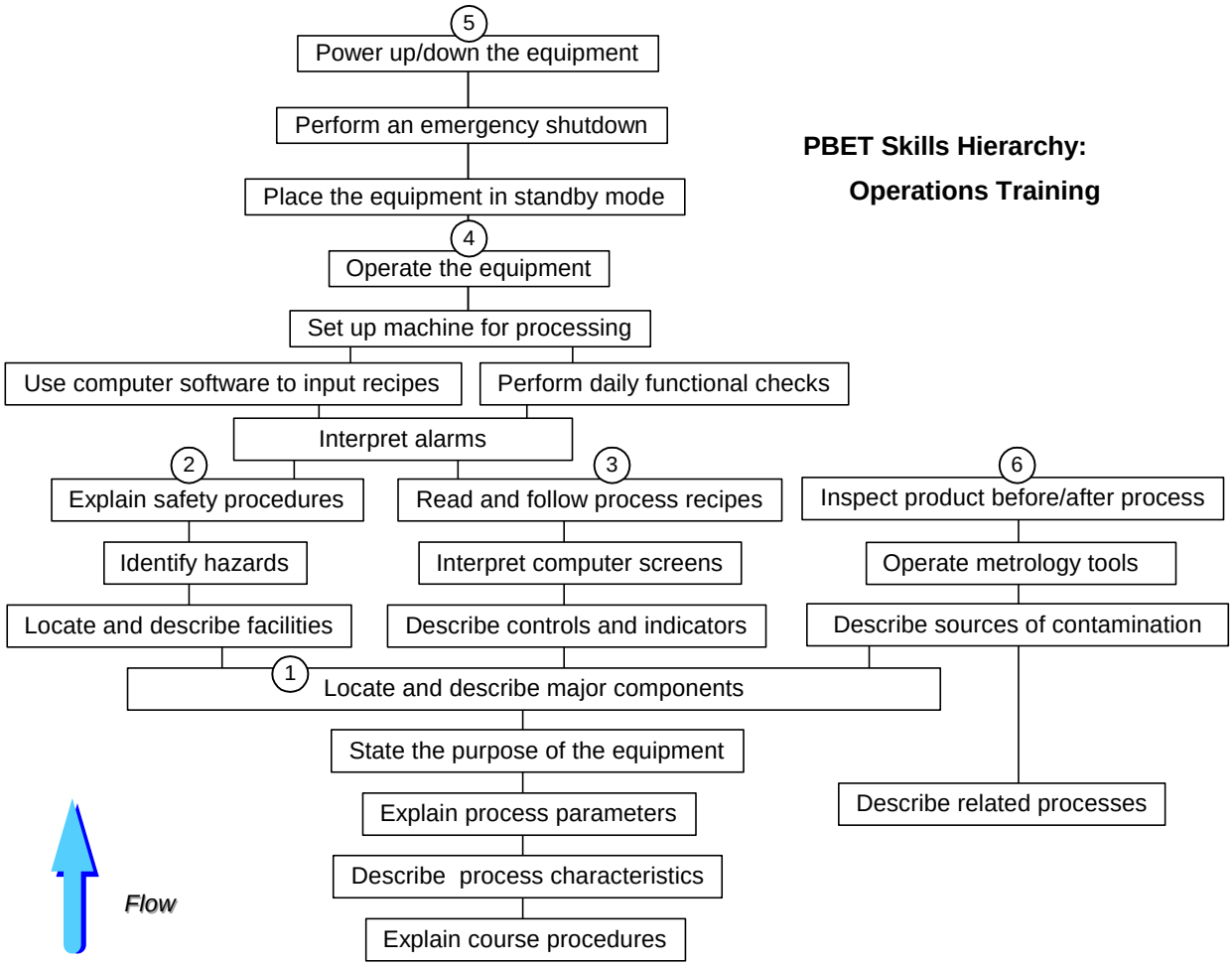


Figure 13 Generic Operations Training Course Map

8.3.4 Materials Development Tracking Chart

The next form is essentially another Gantt chart; however, it is used to plan the development of specific modules within a training course. Once again, depending on the complexity of the project the time scale can be set in terms of days, weeks or months. The first three columns indicate the branch and training modules that would be assigned to an individual author.

#	Branch	Lesson Title	Time Tables in Work Weeks															
			W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26
1	Branch 1	Explain course procedures																
2		Describe process characteristics																
3		Explain process parameters																
4		State purpose of equipment																
5		Locate and describe components																
6	Branch 2	Locate and describe facilities																
7		Identify hazards																
8		Explain safety procedures																
9	Branch 3	Describe controls and indicators																
10		Interpret computer screens																
11		Read and follow process recipes																
12	Branch 4	Interpret alarms																
13		Use computer software to input																
14		Perform daily function check																
15		Setup machine for processing																
16		Operate the equipment																
17	Branch 5	Place the equipment in standby																
18		Perform emergency shutdown																
19		Power up/down equipment																
20	Branch 6	Describe related processes																
21		Describe contamination																
22		Describe metrology tools																
23		Inspect product																

Figure 14 Materials Development Progress Chart

8.4 Adapting PBET Course Materials for Training Development Job Aids

Constructing job aids for course developers and trainers is an important part of continuously improving your training product quality. Properly used, job aids can help assure product quality, uniform structure, best practice procedures and repeatable results.

The following table is included to provide suggestions for creating your own job aids based on the SEMATECH *PBET Participant Guide.* (This document are available on the Internet at the TPIC website, www.tpic.org.) The file is provided in.PDF format, and can be viewed, printed and copied using Acrobat Reader 3.0. Some of the pages mentioned below can be used as-is; others could be merged into a single sheet and formatted as checklists, flow diagrams, or other job aid formats.

Action/Step	Existing Form	Manual Page(s)	PDF File Page(s)	Notes
General				
Learn PBET Development Process	95113011A-TRG PBET Templates	N/A	N/A	Available through SEMATECH web site
"	95103004A-TRG PBET Transparency Masters	N/A	N/A	"
"	95102995A-TRG PBET Participant Guide	N/A	N/A	"
"	95102995A-TRG PBET Instructor Guide	N/A	N/A	"
Build a lesson plan	PBET Lesson Planning Form (Blank)	A-5 & A-6	219-220	Filled in at various steps in the PBET development process
"	PBET Lesson Planning Form Definitions	A-1 & A-2	215-216	"
"	PBET Lesson Planning Form Sample	A-3 & A-4	217-218	"
PBET Step1: Identify the Need				
Perform needs analysis	PBET Simplified Needs Analysis Table	ID-1-6	58	Rework- Last column bold
"	Task Analysis Worksheet	ID-1-7	59	Rework Practice Exercise
PBET Step 2: Analyze the Needs				
Perform task analysis	PBET Task Analysis Worksheet	A-9 & A-10	223-224	
Write performance objectives	Questions and Answers Table 95052836A-TRG PBET Task Analysis Video	AN-2-8	80	Rework Foil
"	Commonly Used Performance Words	AN-2-11	83	
"	Objectives Worksheet	AN-2-12	84	Rework from practice exercise
Develop a skills hierarchy	Skills Hierarchy Example	AN-3-9 through AN-3-	97-99	Combine on one sheet

Action/Step	Existing Form	Manual Page(s)	PDF File Page(s)	Notes
		11		
PBET Step 3.–Design the Course				
Develop skill tests	Requirements for Writing Effective PBET Skill Tests	DS-1-5	107	Rework foil
Describe relevant practice	Four Components of Relevant Practice table	DS-2-2	114	Rework foil
"	Multiple Documents	DS-2-5 through DS-2-8	117-120	Combine on one sheet
Analyze Resource Materials	Multiple documents	DS-3-2 & DS-3-3	130-131	Multiple documents
Select Delivery Method	Training Media Decision Chart	A-11	225	
Summarize the Lesson	Multiple documents	DS-5-2 through DS-5-4	142-144	Combine on one sheet
PBET Step 4: Develop Instructional Materials				
Decide on media	Training Media Decision Chart	A-11	225	
Design of Overhead Transparency Foils	Multiple documents	DV-1-3 through DV-1-6	157-160	Combine on one sheet
Guidelines for Using the Flipchart and Marker Boards		DV-1-7	161	
PBET Step 5: Pilot the Course				
Try out the course	Observation Sheet for PBET	A-13	227	
Assess course performance	Class Performance Record	A-15	229	
"	Individual Performance Checklist	A-17	231	

9 CAREER LADDER FOR EQUIPMENT TRAINERS

The following identifies some of the knowledge and skills necessary for successful completion of specific types of jobs in the field of training.

Table 22 Career Ladder for Equipment Trainers

Job Knowledge or Skill	Technical Trainer		Technologist	Training Supervisor	Training Manager
	Trainer Specialty	Writer Specialty			
Writes test		0	0		
Writes scripts		0	0		
Sketches or draws diagrams		0	0		
Selects proper media mix		0	0		
Defines learning environment needs		0	0		
Discriminates subject matter		0	0		
Derives skills from task analysis		0	0		
Writes maintenance procedures		0	0		
Designs course maps		0	0		
Researches target audience needs		0	0		
Uses presentation software		0	0		
Uses frame grabber software		0	0		
Uses video capture software		0	0		
Uses page layout software		0	0		
Uses hypermedia software		0	0		
Uses CBT software		0	0		
Uses animation software		0	0		
Produces CBT programs		0	0		
Writes pre-tests	0	0	0		
Defines course objectives	0	0	0		
Writes criteron tests	0	0	0		
Creates relevant practice exercises	0	0	0		
Designs and develops job aids	0	0	0		
Conducts pilot classes	0	0	0		
Interacts with other trainers	0	0	0		
Interprets performance objectives	0	0	0	0	0
Interprets task analysis	0	0	0	0	0
Interprets course maps	0	0	0	0	0
Interprets target audience description	0	0	0	0	0
Listens attentively to students	0	0	0	0	0
Evaluates other training programs	0	0	0	0	0
Interacts with customers	0	0	0	0	0
Interacts with contractors	0	0	0	0	0

Table 22 Career Ladder for Equipment Trainers (continued)

Job Knowledge or Skill	Technical Trainer		Instructional Technologist	Training Supervisor	Training Manager
	Trainer Specialty	Specialty			
Solicits students' suggestions	0	0	0	0	0
Suggests alternative learning activities	0	0	0	0	0
Uses telephone frequently		0	0	0	0
Uses E-mail and/or the internet		0	0	0	0
Uses word processor		0	0	0	0
Uses spreadsheet software		0	0	0	0
Writes letters and memos			0	0	0
Sets up A/V equipment	0		0		
Uses presentation media	0		0		
Checks process equipment	0		0		
Operators process equipment	0		0		
Maintains process equipment	0		0		
Troubleshoots process equipment	0		0		
Repairs process equipment	0		0		
Installs process equipment	0		0		
Designs maintenance procedures	0		0		
Provides constructive feedback	0		0		
Instructs technical courses	0		0		
Serves as positive role model	0		0		
Arranges the learning environment	0		0		
Records student progress	0		0		
Interprets questions/forms answers	0		0		
Negotiates for space and equipment	0		0	0	0
Minimizes obstacles	0		0	0	0
Schedules activities	0		0	0	0
Explains course to visitors	0		0	0	0
Makes self available to trainees	0		0	0	0
Reinforces positive behavior	0		0	0	0
Suggests remedial learning activities	0		0	0	0
Recognizes obstacles to training	0		0	0	0
Interacts tactfully	0		0	0	0
Diagnoses performance problems	0		0	0	0
Conducts orientation classes	0				
Listens to personnel concerns				0	0
Coaches staff				0	0
Coordinates work and schedules				0	0
Monitors staff work and performance				0	0
Assigns tasks to personnel				0	0

Table 22 Career Ladder for Equipment Trainers (continued)

Job Knowledge or Skill	Technical Trainer		Instructional Technologist	Training Supervisor	Training Manager
	Trainer Specialty	Writer Specialty			
Submits purchase requisitions				0	0
Makes self available to staff				0	0
Evaluates staff				0	0
Maintains inventory				0	0
Evaluates courses and instructors				0	0
Trains new staff members				0	0
Trains new personnel				0	
Writes reports					0
Writes proposals					0
Prepares annual curriculum schedule					0
Prepares budgets					0
Gives presentations to management					0
Performs needs analysis					0
Formulates training development plans					0
Develops evaluation instruments					0
Removes obstacles to training					0
Recruits new staff members					0
Disciplines personnel when needed					0
Interpret training requests and questions					0
Interacts with other training organizations					0
Interacts with local educational institutes					0
Evaluates supervisors					0
Purchases supplies					0
Approves requisitions					0
Approves personnel requests					0

10 GLOSSARY OF TRAINING TERMS

Accelerated Learning	A methodology that utilizes all of the learner's senses in the learning process – stimulates the learning preferences of individuals with visual, auditory and tactile activities.
Adult Education	Refers to a post-secondary school program provided by schools, training centers, and other related agencies. It is usually job oriented and more adaptable than traditional educational programs
Analogy	A representation (familiar to the audience) which corresponds with an unfamiliar concept in a functional way or form.
Analysis Phase	The process in the Instructional Systems Design model that examines the needs of students and necessary tasks involved with knowledge or skill to be learned. See **Instructional Systems Design** in this glossary.
Behavior	Generally taken to denote observable (visible, audible) actions.
Case Studies	Usually written scenarios that allow students to simulate problem solving or analysis of "real" situations. See **Simulation**.
Competence	Performing a task or a skill to a required level of proficiency.
Competency-Based Training	This training approach focuses on the learner's performance of a specific job or task. (In general) the process of developing training includes a job analysis, identification of skill requirements, training needs, and assessment protocols.
Computer-Assisted Training	An instructional or presentation program that is delivered by way of the computer; however, it may not have the high interaction and branching capabilities of a computer-based training program. Also see **Computer-Based Training**.
Computer-Based Training	A highly interactive instruction course designed and developed on a computer for delivery as a computer-based learning program. Some CBT programs may incorporate onboard user registration and evaluation as well as audio, video, and simulation activities.
Condition	One of three components of a well-stated performance objective that describes the circumstances under which the objective or task is to be performed. The condition statement answers the questions, who, what, when, and where.
Content Analysis	A step in the analysis phase that identifies the essential content for an instructional module.
Content Expert	A person whom colleagues recognize as having certain expertise in the specific area of content related to a corresponding course.

Core Competencies	Identified skills that workers must obtain to perform effectively in their jobs. Also defined as the central or essential skills of a business or corporation.
Course Map	A diagram or flowchart showing the logical sequencing and relationships of objectives or units of instruction in a performance-based or criterion-referenced instructional program.
Criterion	A description of the degree of acceptable, expected, or desirable performance.
Criterion Test	Test by which one finds out whether a performance objective has been achieved.
Criterion-Referenced Instruction	A way of organizing and managing instruction in which pre-specified performance criteria are achieved by each qualified learner (i.e., instructing until the student learns rather than until the bell rings). Synonym for mastery learning.
Demonstration	An observable activity performed by either an instructor or a student to show how a specific task is performed. When performed by a student, a demonstration may be used as a way to show competence with regard to a required skill.
Diagnostic Test	Test by which one finds out why a performance objective has not yet been achieved.
Distance Learning	A communication tool used when students are in different geographic locations. A variety of media formats are employed including video, audio, and computers.
Enabling Objective	A performance objective describing a skill or competence that is an essential element of a larger or more complex competence. Same as sub-objective, subordinate objective, en route objective.
Entry-Level Skills	Skills a student has at the time he or she enters a course. Skills that are over and above the prerequisite skills (and of which an instructor ought to take cognizance but not credit).
Evaluation Levels	Refers to the four accepted levels of training evaluation – participant's reaction, participant's performance, participant's application of skills on the job, and return on investment.
Evaluation Phase	The phase in the Instructional Systems Design model that evaluates the instructional package.
Facilitator	An individual who guides learners in an instructional activity.
Feedback	Information to the student about the adequacy of his performance; information to instructors or course managers about how well the instruction is working.
Goal	An intended outcome not stated in measurable terms.

Hypertext	A term coined two decades ago by Ted Nelson, hypertext is a system of interrelated documents. A hypertext document allows the users to move non-sequentially throughout a document. The system is simple, but very powerful. Two tools: links and nodes, allow any term (node) to be connected (link) to any other term or even the same term.
Independent Study	Typically, a special project or assignment of selected readings for students seeking more information on a course topic. Not to be confused with individualized instruction or with criterion-referenced instruction.
Individualized Instruction	A self-directed approach to education and training. Students direct their own experiences by choosing their own sequence, level of performance, and pace.
Information Mapping	A technique of formatting technical documentation that enhances the reading and learning process. Utilizes tables, charts, graphs, lines and boxes to highlight relationships of content in a document.
In-Service Training	Part-time study of course modules concurrent with one's regular work assignment, in contrast with workshop wherein full time is devoted to study of course modules.
Instructional Aid	Any device (whether written, mechanical, electronic, or other form) that can be used by a trainer, instructor, teacher, or student to help facilitate the teaching process.
Instructional Material	Teaching materials that are used for training activities.
Instructional Objective	A statement of what learners will be expected to do during training. These statements are stated in terms of observable performance. See **Objective**, **Performance Objective**.
Instructional Systems Design (ISD)	Similar to the systematic approach, there are many ISD models used in the development of instruction. The PBET model employs seven major phases (identification, analysis, design, development, pilot, implementation, and evaluation). See **Performance-Based Equipment Training (PBET)**.
Instructional Technology	Usually, the systematic use of formal analysis techniques to design solutions to teaching problems. The solutions are tested and revised until they prove to be effective.
Interactive Media	Instructional tools that enable their users to view various media formats, including text, audio, graphics, and moving images. Interactive media users can alter the sequence of a program.
Internal Training	Training programs that are exclusively for an organization's employees. This is also known as in-house training.

Job Aid	Any device (whether written, mechanical, electronic, or other form) that can be used by a worker to facilitate the performance of a job or task.
Just-In-Time Training	Efficient training programs that require little time and effort to prepare and that can be delivered on short notice
Learning Content Through Process	A technique for teaching the content of a lesson or course by actually taking students through the process of performing the activities of the skill they are supposed to learn.
Learning Objective	See **Objective**.
Learning Style	The preferred method of learning by individuals—usually divided into categories of visual, audible, or tactile.
Lectures	Information transmission by one person.
Lesson	A single unit of instruction designed to cover a short topic or learning objective.
Mastery Learning	A way of organizing and managing instruction in which pre-specified performance criteria are achieved by each qualified learner (i.e., instructing until the student learns rather than until the bell rings). Synonym for criterion-referenced instruction.
Modeling	An instructional method that requires the teacher to perform or demonstrate a job function while students observe this performance or demonstration.
Module	A unit of instruction in a criterion-referenced or PBET course, usually designed for achievement of one objective.
Multimedia	The use of various media formats used either sequentially or simultaneously.
Needs Analysis	The formal process of identifying discrepancies between current outcomes and desired outcomes. An identification of a gap between what is and what should be especially in respect to employee performance.
Needs Assessment	See **Needs Analysis**.
Norm-Referenced Test	Test in which a student's performance is evaluated in relation to the performance of other students, in contrast with a criterion test. See **Criterion Test**.
Objective	A written statement describing an intended outcome in terms of student performance. Same as **Performance Objective**.
On-the-Job Training	The instruction of personnel in the performance of tasks related to the job during the course of normal work functions.
PBET	See **Performance-Based Equipment Training.**

Performance	The observable part of a learning objective which results in the demonstration of a skill or competence.
Performance Objective	A statement in education and training that defines the type of performance, condition, and standard (criterion) of an outcome of intended instructional activity, whether it be in a course or a single unit of instruction.
Performance Technology	A systematic process of identifying and solving human achievement problems. Performance technology solutions involve both training and non-training interventions.
Performance-Based	The implementation and evaluation (of work) performed by the employee. The instructional focus is on the product, accomplishment, or process that the employee must complete on the job.
Performance-Based Equipment Training (PBET, P-BET)	A training methodology adapted by TPIC to help improve the effectiveness of equipment training and to reduce instructional development time. PBET is based on front-end analysis to ensure that qualified participants are able to reach mastery of job skills as described in clearly stated and measurable learning objectives.
Post-Test	Should evaluate all of the stated objectives of an instructional program.
Practice	The act of performing the activities related to a skill under the direct guidance of a mentor or instructor for the purpose of achieving competence in a skill.
Prerequisite	Competencies required by students if they are to benefit from a course. A minimum competence assumed by the course designer to be present in the new student.
Prerequisite Test	A test to determine whether a student possesses the skills needed to benefit from the course. Not the same as a test for entry-level skills.
Pretest	Has items that measure entry behaviors and knowledge that will be taught in the training program
Programmed Instruction	Ideally, instruction that proceeds according to a pre-specified pattern intended to accomplish one or more performance objectives for a specified audience. Patterned instruction; a tested game plan.
Relevant Practice	A structured or planned activity in which students practice the intended performance as stated in an objective.
Role Play	An instructional activity that asks learners to assume different identities, positions, or characters, within the context of a specified problem or situation. This activity facilitates students to understand other perspectives than their own.

Shorthand Objective	A brief form of objective containing only the performance, conditions (when the conditions change the performance), and no criterion.
Simulation	An instructional strategy that teaches by using an abstraction of some real-life situation. See **Case Studies**.
Standard	In training, a measurable criterion used to define an expected outcome, usually stated as part of a learning objective.
Subject Matter Expert (SME)	A person knowledgeable about a particular content area or domain. See also **Content Expert**.
Target Audience	The learners for whom a particular course is designed. See **Target Audience Description**.
Target Audience Description	A written description of the characteristics of the group of people for whom a course is intended. It attempts to describe them as they are, in order to define those who will derive the greatest benefit from the course. See **Target Audience**.
Task Analysis	An organized approach to analyzing a job or task in which all the elements of the activity are defined, including knowledge requirements, skills, equipment, tools, materials, sequencing, number of steps, resources, safety issues, related procedures, and training.
Technical Training	The process of training job-based skills to technical workers: employees who use or apply scientific, mechanical, computer, or mathematical knowledge in their workplace.
Terminal Objective	An objective describing a skill or competence representing a final outcome of a course.
Training	An organized effort to increase the capabilities of individuals.
Train-the-Trainer Programs	Developing knowledge and presentation skills among employees who deliver training, often tailored to a specific course or curriculum.
Virtual Reality	A medium that enables its participants to view a created or “virtual” world. Participants can observe and interact with an environment that is entirely created by computer generated representations.

11 REFERENCE LIST

Anderson, Donald H., *Selecting and Developing Media for Instruction,* Van Nostrand Reinhold, New York, NY, 1983.

Birnbauer, Herman, *The ASTD Handbook for Technical Skills Training,* Volume 2, American Society for Training and Development, Alexandria, VA, 1986.

Bolton, Robert N., *People Skills: How to Assert Yourself, Listen to Others, and Resolve Conflicts,* Simon & Schuster, Inc., New York, NY, 1979.

Bloom, B. S., et al, *Handbook of Formative and Summative Evaluation of Performer Learning,* McGraw-Hill, New York, 1973.

Bloom, B. S., et al, *Taxonomy of Educational Objectives,* Handbook 1: Cognitive Domain, McKay, New York, 1956.

Bower, E. M., and Hollister, W. G. (Eds.), *Behavioral Science Frontiers in Education,* Wiley, New York, 1967.

Boyd, R. D., Apps, J. W., and Associates, *Redefining the Discipline of Adult Education,* Jossey-Bass, San Francisco, CA, 1980.

Bruner, J. S. *The Process of Education,* Harvard University Press, Cambridge, MA, 1966.

Bruner, J. S. *Toward a Theory of Instruction,* Harvard University Press, Cambridge, MA, 1966.

Brunner, E. deS. *An Overview of Adult Education Research,* Adult Education Association, Washington, D. C., 1959.

Cantor, Jeffrey A., "How to Design, Develop, and Use Performance Tests," *Training & Development Journal,* September, 1988, 72-75.

Crow, L. D., and Crow, A. (Eds.), *Readings in Human Learning,* McKay, New York, 1963.

Davidove, Eric A., "Evaluating the Return on Investment of Training," *Performance & Instruction,* January, 1993, 1-8.

Dixon, Nancy M., *Evaluation: A Tool for Improving HRD Quality,* University Associates, Inc., San Diego, CA, 1990.

Eitington, Julius E., *The Winning Trainer: Winning Ways to Involve People in Learning,* Gulf Publishing Company, Houston, TX, 1984.

Fast, Dorothy, "A New Approach to Quantifying Training Program Effectiveness," in *Evaluating Training Programs*, ed. Donald L. Kirkpatrick, American Society for Training and Development, Madison, WI, 1975, p. 47-53.

Gagne, R. M., *The Conditions of Learning,* Holt, Rinehart, and Winston, New York, 1965.

Gilbert, Thomas F., *Human Competence,* McGraw-Hill Book Company, New York, NY, 1978.

Gilly, Jerry W., *How to Collect Data,* ed. Barbara Darraugh, "Info-Line Series," American Society for Training and Development, Alexandria, VA, 1990.

Herzberg, Frederick, *The Motivation to Work,* John Wiley & Sons, New York, 1959.

Herzberg, Frederick, *Work and the Nature of Man,* The World Publishing Co., Cleveland, OH, 1966.

Hilgard, E. R., and Bower, G. H., *Theories of Learning,* Appleton-Century-Crofts, New York, 1966.

Jackson, J. H., and Keaveny, T. J., *Successful Supervision,* Prentice-Hall, Inc., Englewood Cliffs, NJ, 1980.

Kelly, Leslie, *The ASTD Technical and Skills Training Handbook*, McGraw-Hill, Inc., New York, 1995

Kirkpatrick, Donald L., *Evaluating Training Programs-The Four Levels*, Berret-Kohler Publishers, Inc., San Francisco, CA, 1994.

Knowles, Malcolm S., *The Adult Education Movement in the United States,* 2nd ed., Krieger Publishing Co., Huntington, N.Y, 1977.

Knowles, Malcolm S., *The Adult Learner-- A Neglected Species,* Gulf Publishing Co., Houston, TX, 1990.

Leathers, Dale G., *Nonverbal Communication Systems,* Allyn & Bacon, Boston, MA, 1976.

Long, Lori, *Surveys from Start to Finish*, ed. Gerry Spruell, "Info-Line Series," American Society for Training and Development, Alexandria, VA, 1986.

Mager, Robert F., *Analyzing Performance Problems*, Second Edition, Lake Publishing Company, Belmont, CA, 1984.

Mager, Robert F., and Peter Pipe, *Performance Analysis Flowchart and Performance Analysis Worksheet*, available from Center for Effective Performance, Atlanta, GA.

Mager, Robert F., *Developing Attitude Toward Learning,* Second Edition, Lake Publishing Company, Belmont, CA, 1984.

Mager, Robert F., *Goal Analysis,* Second Edition, Lake Publishing Company, Belmont, CA, 1984.

Mager, Robert F., *Instructional Module Development: Preparation,* Second Edition, 15-17.

Mager, Robert F., *Measuring Instructional Results*, Second Edition, Lake Publishing Company, Belmont, CA, 1984.

Mager, Robert F., *Preparing Instructional Objectives,* Revised Second Edition, Lake Publishing Company, Belmont, CA, 1984.

Mager, Robert F., *Troubleshooting the Troubleshooting Course*, Lake Publishing Company, Belmont, CA, 1982.

Mager, Robert F., *What Every Manager Should Know About Training*, Lake Publishing Company, Belmont, CA, 1992.

Margolis, Fredric H., and Bell, Chip R., *Instructing for Results*, University Associates, San Diego, CA, 1986.

Maslow, A. H., *Motivation and Personality,* Harper and Row, New York, 1970.

McKay, Mathew; Davis, Martha; and Fanning, Patrick, *How to Communicate: The Ultimate Guide to Improving Your Personal and Professional Relationships*, New Harbinger Publications, Inc., 1983.

McLagan, Patricia A., *Helping Others Learn: Designing Programs for Adults*, Addison-Wesley, Reading, MA 1978.

Phillips, Jack J., *Handbook of Training Evaluation and Measurement Methods*, Second Edition, Gulf Publishing Company, Houston, TX 1991.

Pipe, *Objectives, Tool for Change*, Pitman Learning, Inc., Belmont, CA, 1975.

Semiconductor Technician Training Workshop Presentation Materials, February 11-13, 1992, Technology Transfer #92020990A-XFR, SEMATECH, Inc., 1992.

Sharon, Amiel T., "Testing...1, 2, 3," *Training & Development Journal*, September, 1989, 30-33.

Shrock, Sharon A., and Coscarelli, William C., *Criterion-Referenced Test Development*, The International Society for Performance Improvement, 1996

Smith, Jack and Merchant, Sharon, "Using Competency Exams for Evaluating Training," *Training & Development Journal*, August, 1990, 65-71.

Smith, Martin E., "Measuring Results" in *Training and Development Handbook*, Third Edition, ed. Robert L. Craig, McGraw-Hill Book Company, New York, NY, 1987, pp. 320-342.

Special Report, "The Consensus Accounting Model," *Training & Development Journal*, July, 1990, S-9 – S-14.

Sudman, Seymour, and Bradburn, Norman M., *Asking Questions: A Practical Guide to Questionnaire Design*, Jossey-Bass, San Francisco, CA, 1982.

Sullivan, Richard L. and Elenburg, Mary Jo., "Performance Testing," *Training & Development Journal*, November, 1988, 38-40.

Tenopyr, Mary L., "Testing" in *Training and Development Handbook*, Third Edition, ed., Robert L. Craig, McGraw-Hill Book Company, New York, NY, 1987, pp. 286-300.

Verderber, Rudolph F., *Communicate!*, Third Edition, Wadsworth Publishing Company, Inc., Belmont, CA, 1981.

Zemke, Ron and Kramlinger, Tom, *Figuring Things Out: A Trainer's Guide to Needs and Task Analysis*, Addison-Wesley, Reading, MA, 1982.

The Technician Performance Improvement Council is cosponsored by International SEMATECH and SEMI (Semiconductor Equipment and Materials International).

http://www.tpic.org