EFFECTIVENESS MEASUREMENT OF A TRAINING PROGRAM DEVELOPED FOR SUPERVISING DISCIPLINE ENGINEERS

by

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ABSTRACT

This research investigates a methodology to effectively assess the development of supervising discipline engineers' management skills resulting from a structured, in-class, development program. Civil, mechanical, electrical, structural, industrial, instrumentation and controls, and process disciplines must work together when designing large engineered projects. In order to stay competitive, engineering firms must find a way to rapidly, but effectively, train their engineers to become qualified leaders in their discipline. They must accelerate the learning of management skills that are necessary in today's industry. A structured, efficient method of training must be developed to provide design professionals with the necessary information without sacrificing day-to-day productivity. In order to determine if the skills development was successful, however, it is necessary to measure the effectiveness of the program.

The first aspect of this research focused on developing a delivery method for a supervising discipline engineer skills development program. An efficient means by which to measure the effectiveness of the program was then addressed. Finally, the resulting data gathered from the program evaluation was analyzed in order to determine whether or not the program was successful in meeting the course objectives. The results of the data analysis revealed that the skills development program had significantly improved the engineering management skills of the participating supervising discipline engineers.

DEDICATION

This thesis is dedicated to my parents. Throughout my entire life, they have challenged me to always do my best. Without their support, none of this would have ever been possible.

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CHAPTER 1

INTRODUCTION

Background

As engineering practices continue to advance, projects around the world challenge the technical skills of design engineers. Engineers of every discipline push their abilities to the limit in an effort to produce the latest design innovations. Civil, mechanical, electrical, structural, industrial, instrumentation and controls, and process disciplines work together in teams to design the world's largest engineered projects. In order to stay competitive, engineering firms must find a way to rapidly, but effectively, train their engineers to become qualified leaders in their discipline.

Training can be defined as the skills, knowledge, or experience gained through a structured process of delivering information (Merriam-Webster 2009). In the engineering profession, college graduation does not mark the end of one's acquisition of knowledge. The engineering industry is a constantly evolving environment. Industry-wide design innovations come about on a regular basis. Hence, engineering firms have turned to alternative means of educating their employees on such practices. They must accelerate the learning of management skills that are necessary in today's industry. In order to do this, a structured, efficient method of training must be developed to provide design professionals with the necessary information without sacrificing day-to-day productivity. Following such a program, the company must then be able to adequately measure the effectiveness of skills development. Measuring effectiveness is the process of determining whether or not the desired results have been produced. In order for

this to occur, there must be a detailed list of objectives stated prior to the training. Some form of evaluation must then be developed to find out if these objectives have been satisfied.

This thesis reports on a program that was recently developed for the Washington Division of URS Corporation (URS-WD). URS Corporation employs more than 50,000 people in a network of offices in major cities in the Americas, Asia-Pacific, the Middle East, and Europe. Formerly Washington Group International, URS-Washington Division provides engineering, construction, and other technical services to a variety of clients worldwide. Much of their work involves power, mining, infrastructure, government, industrial, and environmental management projects. According to George Nash, Executive Vice President of Operations for the Power Business Unit of URS-Washington Division, business continues to grow at more than 25% per year (SDE Development Program Video, 2008). URS-WD is taking on more large projects, many of them in the hundreds of millions of dollars. This expansion requires discipline engineers to gain experience and move into critical leadership roles much faster than they would have a few years ago. In order to achieve this, engineers must go through an extensive training process outside of their everyday work environment.

Objectives

This research has been completed in an effort to develop and measure the effectiveness of a training program intended specifically for supervising discipline engineers. The objectives of this thesis were as follows:

- Research the implementation and evaluation of similar training programs.
- Develop a delivery method for the skills development program on which this thesis was based.

- Develop an efficient means by which to measure the effectiveness of the skills development program.
- Analyze the resulting evaluation data in order to answer the question of whether or not this program was successful in meeting the course objectives.

Research Effort

The program on which this research was based was developed for the training of what Washington Division calls the Supervising Discipline Engineer (SDE). The Engineering Services division of URS-WD consists of engineers covering the mechanical, electrical, piping, structural, instrumentation and controls, and process disciplines. On a given project, the lead technical engineer in each discipline, within a project engineering team, is known as the Supervising Discipline Engineer. This is the first level of supervision within the company. While the discipline engineer mainly focuses on the technical aspect of engineering design, the SDE must be able to balance both a technical and managerial role. The Supervising Discipline Engineer carries many responsibilities throughout the course of a project. Not only are they required to be skilled in their own engineering discipline, but the SDE must also be able to work effectively with engineers from other disciplines. They must possess leadership, teamwork, communication, and management skills. According to Alan Ebner, Senior Vice President of Engineering for Washington Services of URS Washington Division, the SDE is responsible for quality, schedule performance, cost performance, safety, and many other aspects that are vital to project success (SDE Development Program Video, 2008).

When developing a program of such magnitude, a great deal of planning must take place prior to implementation. In the case of URS Washington Division's SDE Development Program,

the planning process began with assembling the program board. Dr. Alan Ebner, Senior Vice President of Engineering for Washington Services of URS Washington Division, came forward as the sponsor for the SDE Development Program. Under the leadership of Dr. Ebner, the board was comprised of representatives from different functions across the company. These representatives were able to provide different perspectives from their various roles within URS Washington Division.

Working together with the SDE Development Program Board, the research completed in support of this program was conducted by The University of Alabama's Department of Civil, Construction, and Environmental Engineering. The program board worked interactively with The University of Alabama research team to develop the objectives for the training program. The purpose and objectives of the SDE Development Program were then addressed in detail in a proposal submitted by the research team to the board.

- Purpose
    1. Primary: Facilitate the transfer of knowledge and understanding of the execution of the engineering discipline work through the full life cycle of a project from experienced and successful SDEs to entry level / new SDEs.
    2. Secondary: Align less compliant/experienced SDEs with the knowledge and understanding of the Project Execution Procedures (PEPs), Global Engineering Standards, and Global Engineering Guidelines for consistent global project engineering execution.
- Program Objectives

    The SDE Development Program must:

1. Define common SDE roles, responsibilities, authorities, and accountabilities with emphasis on the importance of safety, scope, schedule, budget, and quality.
2. Address the importance of completion of prerequisite project documents that clearly define scope, design basis, and execution approach by project management, project support and/or SDEs for an SDE to:
    - Understand overall contracted project and discipline scope.
    - Develop and execution plan.
    - Support the development of the project schedule that depicts the execution plan
    - Prepare a labor control budget to produce each discipline's required deliverables.

    a) Define the documents and the associated project commencement tasks that provide an indispensable and fundamental basis for execution of a project.

    b) Address the need to understand the Scope of Work (SOW) and Design Basis (DB) documents and the prerequisite need to improve the development of the documents (i.e., emphasize the importance of a well defined scope, creation of the Project Execution Plan and Planning).

    c) Emphasize the definition of detailed schedule milestones and discipline interface ties during the development of the baseline schedule.

d) Emphasize and illustrate the use of discipline labor estimating templates and the need to reflect production of deliverables as defined by the SOW, DBD, and Project Execution Plan.

e) Address SDE ownership of the baseline schedule and labor budget as benchmarks for measurement of the Performance Index (PI) and the Schedule Performance Index (SPI). SDEs must be able to determine variances from plan.

f) Address the necessity to define "corrective action" measures to improve any low performance, identify rework and impact, comply with the project's change management process, and meet or exceed the discipline's professional obligations.

g) Convey the importance and benefits of always being proactive. This point will be particularly emphasized in the SDE Development Program.

3. Reference URS Washington Division's Project Execution Procedures (PEP) and the SDE's use of these procedures.

    a) Promote the global engineering vision to consistently execute single and multi-office projects via use of the PEPs and the standard engineering work processes independent of location.

    b) Address the PEPs as viable resources that may sometimes be cumbersome and/or prescriptive but do provide the necessary guidance for consistent performance.

4. Provide case study examples, illustrations, and exercises that provide clarity and understanding to the presentation materials.
    a) Augment the PEPs per section, or sub-section, to provide clarity of the topic.
    b) Provide additional guidance, instructions, metrics, and reminders regarding SDE's oversight of production of deliverables for other disciplines, project and material management, and various project support groups.
5. Define the roles and relationships with other project functions such as with Project Management, Materials Management, Estimating, Project Controls, PDCC, and QA support groups.
    a) The SDE Development Program should particularly focus on the relationship between the primary and secondary roles and responsibilities of the PEM(s) and the SDE(s) on a project.
    b) Address URS Washington Division's responsibility to manage project interfaces with other organizations (stakeholders) involved in the project, including clients, subcontractors, vendors, and internal operational interfaces.
6. Emphasize utilization of SDE supervisory skills to include such topics as effective communication, motivation, leadership, team building, multi-organizational partnering, and others.

With the previously stated objectives in place, the deliverables required to meet these objectives were then addressed. All deliverables developed as a part of this program were submitted to the board for content review and approval prior to the execution of the program. After careful consideration from both parties, it was decided that the training material would be delivered over three separate modules. Module One was comprised of a general overview and presented the structure for the entire SDE Development Program. The first module also addressed concepts and guidance related to the Front End Planning Process of a project. Module Two was constructed around the topics of Project Execution and the Management and Supervision skills necessary for successful deliver of the work. Finally, Module Three of the SDE Development Program specifically focused on topics associated with closing out the construction phase of a project, the complex process of transitioning to operations, and team building and leadership skills. Table 1 contains a detailed list of the content covered in each module.

Table 1

SDE Development Program Deliverables

Module One: Front End Planning	Module Two: Project Completion	Module Three: Project Completion and Team Dynamics
Introduction	Introduction	Project Start-up
Understanding Objectives	Project Execution	Project Close-out
Feasibility Phase	Risk Management	Team Building Concepts
Concept Phase	Contract Management	Leadership Applications
Detailed Scope Phase	Change Management	Mentoring Responsibilities
Contractual Relationships	Constructability	Career Development
SDE Roles and Functions	Design Control	Role of the SDE in Review
	Work Breakdown Structure	
	Cost Management	
	Schedule Management	
	Calculating Variances	
	Materials Management	
	Information Management	

The intent of these three modules was to address best practices throughout the industry, URS-WD policies and procedures, and management skills beyond the specific engineering design discipline technical skills. During the program, engineers were educated through numerous lectures, interactive workshops, and intermediate assignments. The specific means in which these three modules have since been delivered will be addressed in the following sections.

So, how can discipline engineers be trained to prepare them to take on the role of a supervising discipline engineer, and how can the effectiveness of this training be measured? This research team looked first at how some of the available literature has addressed in-house training for engineers and how that training was evaluated. Next, a methodology was chosen for the SDE Development Program. Then, the self-assessment survey was developed. Finally, the data was collected, analyzed, and used to determine whether the chosen methods were successful in meeting the objectives.

CHAPTER 2

LITERATURE REVIEW

Importance of Training

Training is vital to the success of the practicing discipline engineer. Both specialization in some specific areas and a general knowledge of a variety of different areas are needed in order to stay competitive with other major firms around the world. In addition, the current global nature of the industry further complicates the execution of successful projects. Business management, human relations, and organizational development skills are all necessities for engineers looking to advance in their careers. One method of providing engineers with this knowledge is through training (Kuprenas, Haraga, DeChanbeau, & Smith, 2000). According to Farr and Sullivan (1996), “Learning is a lifetime endeavor for engineers.” Training has thus become a major cost of doing business. By providing adequate resources, however, training allows engineers to develop management skills at a much faster rate.

Training Methods

The question then becomes, how can effective skills development programs be delivered to discipline engineers without causing unnecessary stress on both the employee and the company? To this point, there seems to be minimal literature documenting the training of discipline engineers. According to Farr and Sullivan (1996), the majority of professional training programs are still delivered in a classroom-oriented environment. For this type of training, an instructor prepares and controls the learning experience. When properly prepared and delivered,

this is a highly effective means of training engineers (Farr & Sullivan, 1996). Alternatively, the recent advances in communication and multimedia technology have created other options for in-house skills development.

Thanks to the continuous advancement of multimedia technology, networking abilities, and video teleconferencing, the communication between experts and employees has been made much easier. In-house, technology-based training provides a readily accessible, less formal, less costly and contextualized means of educating employees. When the need arises, employees can reach across organizational boundaries in a much more convenient manner (Farr & Sullivan, 1996). However, this type of training also has its potential drawbacks. Because this is most likely done in the office, the employees, or trainees, can be easily distracted by office activities. Current projects and constant emails and phone calls can cause an employee to not give his or her undivided attention to the training at hand. Also, because it is less formal, there is the potential for trainees to not take the program seriously. Finally, because the training is done outside of the classroom environment, trainees often miss out on hands-on activities and one-on-one instruction. Personal interaction with co-workers and instructors is an important aspect of the learning process. The lack of hands-on team activities takes away from the skills development experience.

On the other hand, the classroom-style training program eliminates many of the drawbacks associated with technology-based training. However, when a company decides that this form of skills development program is necessary, there is much to consider. Will the instructor be a qualified employee within the company, or will expertise have to be acquired from outside the organization? Is the training going to take place in the office or at an off-site

location? How long will the course last? These questions and many more must be answered during the planning of such a skills development program.

Tenorio, Maiam, and Grant-Tenorio (1997) discuss a model for in-house industrial training. Industrial education programs can be very challenging. In comparison to programs used in a university setting, industrial training typically requires a condensed course schedule. At a college or university, classes typically allow a few months to cover a specific topic. In the professional world, companies do not have this luxury. For this reason, employers must find a way to train their employees in only a few days. Workers do not have the ability to escape their everyday duties for months at a time. Because of this, training programs must be efficiently planned and coordinated. (Tenorio et al., 1997).

In this example of an in-house training program addressed by Tenorio et al. (1997), class participants attended courses for 8 hours a day, 5 or 6 days a week. Typically, 14 to 24 participants were in attendance at each course. Daily activities included lectures and supervised assignments. Some of these assignments may have even required a written report developed by the individual or by the team. Throughout the course, supervision was provided by the designated instructor as well as by qualified assistants with familiarity of the details of the given assignments (Tenorio et al., 1997).

Due to the intensity of such a development program, the learning environment is a crucial detail that must be considered. Tenorio et al. (1997) placed emphasis on the importance of the training atmosphere. Class participants had to be able to concentrate and focus solely on the material being presented. They required freedom from any distractions such as phone calls, emails, and problems pertaining to their work. Ideally, participants should have been allowed to direct all of their attention to the course content. In order for this to be possible, this type of

training program is typically held at a study center. Generally, hotels or conference centers are the ideal locations to provide a good study environment. Accommodations at this type of study center provide everything that the participant needs to focus on the task at hand. With everyone staying at the same location, class participants are able to gain immediate feedback and guidance from the program instructors (Tenorio et al., 1997). In addition, by secluding trainees from the distractions of their everyday work environment, the training is immediately perceived as important (Kuprenas, Madjidi, & Alexander, 1999).

Methods of Measuring Training Effectiveness

In Mitchell's (1998) trainer's handbook, he provides an excellent definition of training evaluation:

> Training is the business of bringing about change. To know whether you have achieved change, you must be able to evaluate the effects of your instruction. You have defined objectives and determined what the change should be. You have assessed the present status and have a program for changing it to meet those objectives. Now you need a means of measuring the success you have achieved. This last step is evaluation. (p. 129)

Evaluation is a crucial aspect of the training process. Without it, there is no way to know if the information being delivered was effectively communicated and received.

According to Mitchell (1998), there are three levels of change in performance that must be evaluated in order to measure the success of a training program. Level One refers to how well the participants have received the information that has been communicated to them. All participants should understand the key concepts and be able to perform the skills leaned throughout the program. This evaluation is to take place during and upon completion of the skills development process. Level Two is the evaluation of the engineers' performance as they return to their everyday work environment. For the training program to be truly considered effective,

the program participants must be able to transfer what they have learned to the workplace. This can be referred to as the level of implementation that has occurred since the conclusion of the training. In order to evaluate this level of effectiveness, employee performance must be observed over a period of time. Finally, Level Three is the measurement of how the department or company has been impacted by the course. This is typically evaluated by calculating the dollar return on the money investment by management in training. Continuous evaluation can benefit both the facilitator and the participants. It allows the instructor to receive feedback on whether or not he or she was successful in delivering the material in a desired manner. On the other hand, evaluation also allows the trainees to see where they are in the training process (Mitchell 1998). Because the training program on which this research was based is a recent development, Level One and Two evaluations have been the primary focus.

Level One Evaluation

A Level One evaluation typically involves some form of task assigned by the instructor to be performed by the student. Based on the trainees' performance of this task, the instructor receives feedback on how well the information that he or she provides is being mastered. This type of evaluation also lets the class participants measure how successful they have been at learning. Mitchell (1998) provides numerous ways in which a Level One evaluation can be performed. Exams, Socratic questioning, project sessions, spot quizzes and reviews, and assessment sessions are among the popular ways to measure effectiveness during and shortly after a training program. Evaluation techniques such as spot quizzes, project sessions, and flip chart exercises can be used to continuously check progress during the actual program. Participants will often be divided into teams and asked to perform some kind of task as a group.

Each team will then report their findings to all class participants as well as the instructor. In contrast, examinations and assessment sessions will most likely be used to evaluate the course as a whole. Many times, some form of examination will be given prior to the training program and then again at the conclusion. This allows the instructors and trainees to measure the progress made throughout the program (Mitchell, 1998). The effectiveness measurement method that was chosen for use during the SDE Development Program will be discussed in detail in the following chapters.

Level Two Evaluation

Level Two evaluations pay close attention to the transition of class participants from the training program back to their jobs. If the information gathered through training is not transferred and utilized in the everyday work environment, then the training would seem to be a waste of time and resources. For training to be successful, upper management must be accepting of the newly developed employee skills and allow them to be implemented at the workplace. It is important to work closely with supervisors while developing such a program in an effort to minimize the risk of resistance to the learning. According to Mitchell (1998), there are several ways to avoid such difficulties. By mandating post-training action plans, requiring post-training surveys, and holding follow-up sessions, the transition can be made much easier. In addition to helping provide a smooth transition from training to implementation, supervisors will also play a key role in measuring how well the skills learned through training have been utilized in everyday activities. It is often hard for the trainee to see how well he or she has used the skills gained through training during their work days. Sometimes it takes an outside observer to be able to see the whole picture. By evaluating the previously mentioned process of implementation,

supervisors and upper management are able to see just how effective the training program was. This evaluation may take place over a span of months or years, but it is a necessary step in measuring the effectiveness of a training program (Mitchell 1998).

Level Three Evaluation

Finally, Level Three involves a bottom-line evaluation. Although training is necessary for continuous learning, it must be done in the correct manner in order to receive the desired results. The ultimate success of a training program can be seen in the actual bottom-line. Mitchell's (1998) third level of evaluation measures effectiveness based on the return on investment. The training program must provide the desired increase in performance in order to justify the high cost of program development. A company may base the success of training on actual money saved, improved performance, satisfied clients, or an increase in efficiency. Either way, this level of evaluation must take a look at the company as a whole. This measurement may take years before coming to the conclusion of whether or not the training was successful in changing the performance of an organization (Mitchell, 1998). Although this level of measurement was not directly performed here, this research has provided the foundation for a third level of evaluation to be performed somewhere in the coming years.

Case Study

The development of a successful training program and measuring its effectiveness can be further illustrated through a relative case study. This case study examined a program developed to educate engineers in the area of project management. The delivery and evaluation methods used during this project showed some distinct similarities to those chosen for the SDE

Development Program. The evaluation structure used in this case study also closely resembled the levels described previously by Mitchell (1998). In an article written by Kuprenas et al. (1999), the authors addressed the development of a project management training program for the City of Los Angeles's Department of Public Works. This is the department that "creates and maintains the physical framework and underpinnings of one of the most geographically, economically, and ethnically diverse cities in the world" (Kuprenas et al., 1999, p. 47). The Department of Public Works consists of seven separate bureaus and is responsible for the construction, renovation, and operation of city facilities and infrastructures. One of these seven bureaus is the Bureau of Engineering. It contains over 1,000 employees and holds the responsibility of the planning, design, and construction management of the city's capital improvement projects. Such projects typically include storm water and sewer systems, streets, and other infrastructures. In past years, the Bureau of Engineering has produced designs that exceed satisfactory standards and remain well within the industry norms. However, some of these capital projects have been plagued by significant delays and cost overruns during the design and construction phases. In an effort to improve project delivery and restore confidence in the Bureau's ability to successfully manage projects, a project management training program was developed.

> The Bureau's implementation of a project management approach consisted of three key elements:
> 1. Establishment of the project management organizational structure
> 2. Clearly defined roles and responsibilities for project delivery team members
> 3. Training of the Bureau workforce in program project management principles and tools, (Kuprenas et al., 1999, p. 47)

Kuprenas et al. (1999) goes on to state that in order to meet the objectives developed for this program, employees would be trained in the areas of system optimization, project management technical tools, and human relations/organizational development (HR/OD). The

program would be held at an off-site location in an effort to create the optimum learning environment. By doing this, trainees realize the importance of the program and are separated from any distractions. To complete the planning on such a large project, a training management team (TMT) was organized to coordinate over 30,000 hours of training given to over 1,000 employees. One of the most challenging tasks for the TMT was evaluating the effectiveness of the program itself. The team identified four different levels of effectiveness measurement. These four levels included measuring the instruction, measuring the learning, maintaining the learning, and utilizing the learning (Kuprenas et al. 1999). As mentioned previously, the levels of measurement are very similar to those discussed in the previous section.

In Mitchell's (1998) evaluation structure, measuring the instruction and the learning was combined into the Level One evaluation. Kuprenas et al. (1999) had performed a similar evaluation but had broken the measurement of instruction and learning into separate levels. For the SDE Development Program research, the amount of learning that had taken place was the primary concern. Measuring the learning focuses on the comprehension of information by the class participants. If the learned skills are forgotten the moment training is completed, then the program is not successful in meeting its objectives. In the program examined by Kuprenas et al. (1999), the training management team came together to discuss how to best evaluate the effectiveness for this level of learning. Two evaluation methods were examined and utilized. First, each trainee was required to take part in a post-instruction interview. This method was used to basically make sure that all attendants were able to remember the key points addressed throughout the training sessions. If these key points could not be remembered, then learning had not taken place. The second method of evaluation utilized pre-training and post-training quizzes. By examining both quizzes from each trainee, the TMT was able to see if knowledge of the key

course concepts had improved over the course of the training program. In some cases, this method caused trainees to fear that the quizzing could reflect poorly on them as employees. However, the goal of the quizzes was actually to evaluate how well the instructor had presented the information. Because of this, the TMT continued to use this method but allowed the program participants to use pseudonyms in order to remain anonymous. In conclusion, the second level evaluation found that the training program was in fact successful. Quiz grades saw a significant improvement when comparing pre-training and post-training scores (Kuprenas et al., 1999). Although these were not the exact methods used to measure the effectiveness of the SDE Development Program, this improvement in level of understanding is what the research team has looked for throughout the evaluation.

Closing Remarks

The engineering and design of large industrial projects is a highly technical and complex process. Such an environment requires the guidance of qualified supervisors. For firms to remain competitive in this continuously advancing field, the skills of management, communication, and leadership must be developed at a rapid pace. This process of developing engineers into supervisors in their field can happen much faster by using efficient skills development programs. However, these programs must be properly developed and then evaluated. Such training programs require a great deal of time, effort, and resources. Nevertheless, a well-developed program can add value to the company that far surpasses the initial cost.

Mitchell's (1998) method of evaluation provides a well defined structure for measuring the effectiveness of training. However, similar research has also been done by Kuprenas et al. (1999), as stated in the previous case study. Regardless of the chosen guidelines, the evaluation

of a training program must be conducted by determining how well the program was able to satisfy the predefined objectives. This requires reviewing the program needs, examining how the program was conducted, and developing a means of measuring effectiveness. Evaluation must go beyond how well the participants liked the course and how they would rate the instructor (Kuprenas et al., 2000). Constant, detailed evaluation provides the necessary feedback needed to make sure training programs are effectively delivering the desired information. Training is used to bring about change, and evaluation is absolutely necessary to measure that change (Mitchell 1998). Mitchell (1998) writes, “We don’t evaluate just to prove we did something, but rather to improve how we do it in the future” (p. 150). The sole purpose for measuring training effectiveness is to find out how well a program has been conducted and what can be done in the future to make it even more successful.

CHAPTER 3

METHODOLOGY

Introduction

As discussed earlier, two crucial parts of the planning process involved the decision of how the information should be delivered and how the program would be evaluated. Every skills development program is unique and must be tailored to meet the desired outcomes. With the content of each module assembled as described previously in Table 1, the delivery method had to be chosen. Time, location, instructor, and facilitation style were among the details that had to be worked out long in advance. In the case of URS Washington Division's SDE Development Program, these decisions were addressed by the program board and The University of Alabama research team. Much like the training management team (TMT) from the previously mentioned case study, the SDE Development Program Board was in charge of planning the details of the course and reviewing all program deliverables. The board, along with the research team, also determined the best possible way to measure the effectiveness of the training. A great deal of effort and resources were used during the preparation stage of the SDE Development Program. However, this level of planning was an absolute necessity for the development of such a program. In this next section, the methods of training and evaluation that were chosen and utilized throughout the SDE skills development program have been discussed.

Delivery Method

The SDE Development Program Board wanted to make sure that the engineers selected to attend the course understood that this was important and that they should feel honored to be a part of such a program. Each participant was selected based on competent performance within their engineering discipline and their potential to rapidly promote into roles with greater levels of responsibility. This program allowed the trainees to refine their engineering management and leadership skills, providing them the opportunity to escalate into a supervising position. Class participants needed to understand the importance of giving their undivided attention to the materials being presented. For this very reason, the SDE Development Program was implemented using a classroom style environment.

The three modules of the program discussed earlier, Front End Planning, Project Execution, and Project Completion and Team Dynamics, were developed as three separate classes. The modules were presented over the course of 3, 5, and 2 days, respectively. Each class consisted of 25 engineers from various disciplines. Since 10 total days was a great deal of time for these participants to be away from the office, the modules were taught with about 1 month between each session. This not only prevented participants from being away from their work for such an extended period of time, but it also allowed them to take time and reflect on what they had learned from the previous module before diving into more material. Also, the location of the program changed from module to module. With office locations in numerous major cities across the country, the program location was moved for each module.

Table 2

SDE Development Program Locations

Module	Class 1	Class 2
One	Birmingham, Alabama	Princeton, New Jersey
Two	Denver, Colorado	Birmingham, Alabama
Three	Princeton, New Jersey	Fort Mill, South Carolina

The URS Washington Division offices listed above in Table 2 served as host sites for the SDE Program modules. However, the actual training was held away from the office in a nearby hotel/conference center. This allowed the instructors and class participants to stay in the same location. Time was used efficiently, and distractions were held to a minimum. The overall goal in using this type of training program was to create the optimum learning environment.

Another equally important consideration regarding the training program was how the actual material was delivered. This was done under the guidance of Dr. W. Edward Back, head of The University of Alabama research team. Assisting Dr. Back in program facilitation was Dr. G. Edward Gibson, Dr. Philip Johnson, and graduate students Clayton Ingram and Robert Morriss, also of The University of Alabama research team.

- Dr. Back has completed approximately $4 million of funded research and has taught graduate level university classes in project management best practices, contract administration, risk management, simulation of construction operations, project controls, estimating, scheduling, productivity, and materials management. He has also authored over 45 unique project management courses and has taught over 2000 industry professionals.
- Dr. Gibson has completed over $8 million of funded research and has taught graduate level university classes in project management, front end planning, alternative dispute

resolution, international project administration, information systems, contract delivery methods, and infrastructure management systems. He has conducted over 170 industry short courses on various project management topics worldwide. Among many other publications, he is the author of all Construction Industry Institute's Front End Planning products including the Project Definition Rating Index (PDRI).

- Dr. Johnson has completed greater than $1 million of funded research and has taught graduate-level university classes in civil engineering materials, construction engineering, construction administration and finance, construction methods and estimating, construction management, construction internship, and forensic engineering. He was the founder of the UA Construction Engineering program and also leads UA's Engineers without Borders program, traveling with engineering students worldwide.

In addition to The University of Alabama research team, members of the board from URS Washington Division were also present during facilitation to provide valuable input on certain matters pertaining to company procedures.

Under the instruction of the previously mentioned facilitators, each module was implemented utilizing a pre-class assignment, lectures, workshops, flipchart exercises, discussions, and a post-class assignment. First, prior to each module, a pre-class reading and writing assignment was distributed to the participants. This task was to be completed and a written response turned in before the start of the program. Then, using a slideshow presentation, the instructors delivered the outlined material in a classroom-style setting. These lectures were intended to be interactive discussions among participants and facilitators to provide the participants with the terminology and skills pertaining to industry best practices and engineering

management as stated among the program objectives. Following certain important topics within each session, a related workshop was used to reemphasize what had been learned during the lecture. Participating engineers were divided into teams and asked to perform a certain task before presenting their findings to the instructor and the rest of the class. These teams were deliberately mixed with engineers from various disciplines. This was done in order to encourage participants to learn to communicate and work with engineers from various fields. Flipchart exercises and discussions were also used throughout the presentations in order to keep the class participants involved and allow them to present their own ideas. The goal throughout each session was to create an interactive learning environment for the program attendants. Following the conclusion of each module, participants were then given a post-class assignment. Similar to the pre-class assignment, attendants were asked to complete a reading and provide a written response utilizing the information learned during the SDE Development Program. In addition, the engineers were given numerous resources to guide them throughout the training. Each participant received a binder containing the instructor's presentation so that they were able to follow along. Handouts were distributed to reinforce the delivered material. Finally, the trainees were also given a USB flash drive containing even more documents, outside reading/reference material, and valuable tools related to the training topics. Upon graduating from this skills development program, class participants had obtained the resources needed to be able to take what they learned and apply it in their everyday work environment. Once the implementation of all three modules was complete, the next step in the process was to develop a means of measuring the effectiveness of the program.

Method of Measuring Effectiveness

Choosing a method by which to evaluate this type of training program presented a great challenge. The success of a training program depends on the ability of the participants to learn and retain the information presented. As seen previously, there are numerous ways to perform such an evaluation. For the sake of this research, the main focus was to evaluate the program based on the participants' improvements in level of understanding regarding the material presented. This relates back to the Level One and Level Two evaluations discussed in chapter 2. Thus far, the SDE Development Program has been completely delivered twice, both within the past year. For this reason, it was not possible to make an accurate evaluation of the skills development program's long-term impacts seen by URS Washington Division. However, a very good evaluation was made on how well the trainees learned the information and skills introduced to them during the program. First, the trainees were evaluated throughout the course of the program to make sure they stayed on track. The bigger challenge, however, came when trying to make a comparison between the trainees' knowledge prior to the training versus their knowledge of the material after the training was completed.

First, in-class evaluation methods were examined. Although it may not have seemed like a form of evaluation at the time, the previously mentioned workshops, flipchart exercises, and discussions served as a means for both facilitator and engineer to see how well the learning was taking place. Workshops allowed program participants to take the skills learned during lectures and apply them to a real-world situation. They were required to work together with a team just as they would on the job. Ideas were collaborated until a uniform decision was made. The team then came back with a report of their findings. Instructors were able to see if the key aspects of the related topics were learned and properly utilized. Flipchart exercises and discussions provided

much of the same. The instructor was able to challenge the engineers to relate the course material to current projects that they may have been working on. This was a simple but effective type of evaluation that gave immediate feedback for both parties.

On the other hand, measuring the effectiveness of the training program as a whole was a much more daunting task. In order to do this, it was necessary to find a way to measure the change that occurred during the skills development program. An evaluation of pre-training knowledge versus post-training knowledge was required. However this was to be done, the effectiveness of the program largely depended on the significance of the change that occurs. Simply asking a few questions in a post-training interview would not suffice for this level of evaluation. The method of measurement used here had to go into enough detail to determine whether or not the objectives of the training program were achieved. Several methods have been used to complete this level of evaluation. Among these, giving pre-training and post-training examinations was one option that has proven to be effective. This was seen in the research completed by Kuprenas et al. (1999) as it was described in detail throughout the case study from chapter 3 of this thesis.

Examinations can be used in many cases, such as college courses and professional licensure exams, to evaluate the knowledge of a certain individual. The ability of the person to retain information is defined by the grade that is received. The same is the case for a skills development program. In this instance, however, two examinations are given; one prior to the training program and another upon completion. The difference seen between the two examination grades shows the amount of change that took place during the training. One can then determine whether or not the change in percentage was statistically significant. In other

words, was there enough of a change to call the program a success? However, there are two main problems with this type of evaluation:

- First, the word examination often brings an uneasy feeling to the class participants. They may feel unnecessary pressure to perform, thinking that a poor grade on the final examination could reflect badly on them in the eyes of their superiors.
- Secondly, the program developers can tailor their training material to produce good test scores. They may spend excessive amounts of time covering the material addressed in the exam, possibly leaving out some key issues included in the course objectives. Even though everyone may correctly answer one hundred percent of the questions on the examination, the data that is produced may be misleading.

For these reasons, The University of Alabama research team decided to find another means by which to perform the SDE Development Program evaluation.

The method that was chosen to measure the effectiveness of URS Washington Division's SDE Development Program was a detailed self-assessment survey. The term survey can sometimes be taken in the incorrect manner. This survey was not designed simply for the participants to rate the facilitator and state whether or not the program was a valuable learning experience. The self-assessment survey was developed to allow each class participant to complete a detailed assessment of the knowledge that they gained over the course of the SDE Development Program. Each engineer was asked to reflect on his or her learning experience during the program and then rate his or her pre-training and post-training knowledge of the developed list of evaluation criteria. This list was designed to cover all of the major topics as they were presented in the course objectives. The intention of the survey was not to merely measure the engineers' awareness of the material. The self-assessment survey was designed to

evaluate the participants' ability to perform the skills introduced throughout the course. In addition, class participants were also asked to rate the level of implementation that had occurred in their everyday work environment since the conclusion of the training program. The details of how this survey was developed are addressed in the following chapter.

Closing Remarks

There were some key advantages to utilizing a self-assessment survey versus a traditional examination-style evaluation. The trainees were given some time to reflect on what they had learned. The survey was sent out at a later date rather than being given a test immediately following an intense few days of training. No grade was given, so the class participants were able to give an honest self-evaluation of the knowledge gained through training. By assuring participants that their responses were merely being used to measure the effectiveness of the learning, program developers received a very thorough evaluation of the training. In the end, the data received from the self-assessment survey was very similar to that of an examination-style evaluation. The amount of change that occurred throughout the training was measured. This was simply a different way to approach the evaluation process and avoid the negative connotation associated with some type of test. Although the self-assessment survey was not the only available method of evaluation for a skills development program for discipline engineers, it was decided that this was the best and most appropriate way to measure the effectiveness of this specific program.

CHAPTER 4

SURVEY DEVELOPMENT

Introduction

As discussed in the previous chapter, the effectiveness of the SDE Development Program was measured using a detailed self-assessment survey. This survey was developed by The University of Alabama research team in an effort to analyze how well the skills development program was able to meet the objectives stated prior to the course. In developing this survey, the goal was to provide a detailed assessment of the engineers' knowledge but keep it short enough for them to complete in a reasonable amount of time. The challenge came in finding that balance. A survey that was too short would have not been able to provide an accurate assessment of the program as a whole. Many key topics may have been left out simply by limiting the number of questions on the survey form. On the other hand, a survey that was too long would have caused respondents to rapidly lose interest. No one wants to sit down and complete a survey that covers 300 questions and takes 2 hours out of their day to complete. Respondents would have become frustrated and focused on finishing the survey quickly rather than giving the most accurate assessment possible. The result of this would be data that may not reflect the engineers' true knowledge of the material. To prevent this from occurring, the research team and the program board decided that the developed survey should have taken no more than around 30 minutes to complete. Questions were required to be short and to the point, and there had to be a convenient way for the completed survey to be returned. Such were the guidelines that were followed in the development of the SDE Development Program self-assessment survey.

Evaluation Criteria

With the survey guidelines in mind, each module of the program was examined individually to develop a list of criteria by which to evaluate the participants' general knowledge on a number of key subject matters. The most important topics from the Front End Planning, Project Execution, and Project Completion modules were restated in the form of questions pertaining to the engineers' understanding of the material. After carefully reviewing each individual module, a total of 104 key topics were drafted into statements relating to the participants' understanding of each subject. The Front End Planning portion of the survey consisted of five major sessions and a total of 36 questions. Feasibility, concept, detailed scope, and contractual relationships were among the main topics. Next, the Project Execution module produced the most robust section of the three. It covered the most material and thus required the most questions in the assessment. Fifty total questions among 12 sessions touched on topics such as risk management, change management, constructability, and cost and schedule management. Finally, the shortest of the three modules, Project Completion and Team Dynamics, was reviewed. This section of the survey included five sessions and 18 questions relating to project start-up and close-out, teambuilding concepts, and leadership applications. All of the questions included in the survey were made as concise as possible. This allowed respondents to briefly read each evaluation criteria and rank their level of understanding quickly and accurately. Given the number of evaluation criteria used, class participants should have been able to complete the self-assessment survey in about 30 minutes.

With the evaluation criteria determined, the next step was to develop the actual survey format. In an effort to minimize the amount of paper used during the evaluation process, the SDE Development Program board from URS Washington Division requested that this be done in

electronic form. To meet this requirement, the respondents had to be able to receive the survey by computer, complete it, and return their answers in similar fashion. For this reason, the self-assessment survey was created using Microsoft Excel. Each question was placed into an individual cell within the spreadsheet. Beside each of these questions, trainees were asked to rate their level of understanding on each topic on a scale from 1 to 5: 1 = *Little*, 2 = *Some*, 3 = *Average*, 4 = *Much*, and 5 = *Proficient or Expert*.

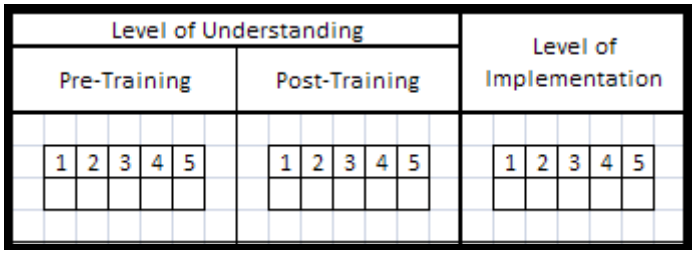

Figure 1. Self-Assessment Survey Rating Scale.

As seen in Figure 1, the program participants were also asked to rate the level of implementation that had taken place since the conclusion of the training. Rather than having them rate each and every question, only the major session topics were evaluated for level of implementation. The scale used for rating the level of implementation was the same as above. The complete SDE self-assessment survey can be found in Appendix A, but a sample of the self-assessment survey has been illustrated in Figure 2.

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

	Evaluation Criteria - General Knowledge	Level of Understanding: Pre-Training	Level of Understanding: Post-Training	Level of Implementation
Front End Planning	**Understanding Objectives**			1 2 3 4 5
	Understand that objectives are defined as the success criterion.	1 2 3 4 5	1 2 3 4 5	
	Understand that there may be multiple alternatives that may satisfy the objectives for the project.	1 2 3 4 5	1 2 3 4 5	
	Understand that project performance measures are not the same as project objectives.	1 2 3 4 5	1 2 3 4 5	
	Understand that the phases of objectives setting include formation, communication, and integration.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance for objectives to be specific, identifiable, attainable, controllable, assignable, and realistic.	1 2 3 4 5	1 2 3 4 5	

Figure 2. Sample of Survey from Front End Planning Module, Abridged.

The portion of the survey depicted in Figure 1 came from the Front End Planning module. The first session of the Front End Planning course related to Understanding Project Objectives. As you can see, the SDE participants were first asked to rate how the skills learned from the Understanding Objectives session have been implemented in the workplace. They were then required to rank their pre-training and post-training level of understanding regarding each individual evaluation criteria. The amount of change that occurred was then calculated by taking the difference between the pre-training and post-training response. For example, if a respondent rated the first question with a 1 prior to the training and a 5 after the training, then a 4-point change had taken place. The effectiveness of the training depended on the magnitude of the change that had occurred.

The SDE Development Self-Assessment Surveys were distributed following the conclusion of the program. Both pre-training and post-training assessments were completed at the same time. This was to prevent an inaccurate assessment of pre-training knowledge. A participant may have initially thought that he or she was an expert in a certain area when, in fact, they knew very little. Recognition of what the participant knew coming into the class could only be accurately assessed after the conclusion of the skills development program.

Closing Remarks

The format described above and seen in Figure 1 was utilized throughout the entire development of the SDE Development Survey. A complete copy of the SDE Development Program Self-Assessment Survey has been included in Appendix A. The assessment method not only provided a simple means for distributing and returning the surveys, but it also allowed the data to quickly and efficiently be collected and analyzed. Upon the completion of the survey development process, the self-assessment form was turned over to the board for a content review. Following a few minor adjustments that were made at the request of the board, the survey was ready to be distributed. Details of the distribution method and data collection are discussed in the following chapter.

CHAPTER 5

DATA COLLECTION

Distribution Method

With the self-assessment survey completed and approval granted from the program board, the next step was the distribution of the material. As it was stated previously, this was required to be done electronically. The survey was to be distributed to every engineer who had completed all three modules of the SDE Development Program. With the help of URS Washington Division, the self-assessment forms were sent via email to all of the program participants. This included a total of 50 engineers. Participants received an email that included a brief note from upper management emphasizing the importance of completing and returning the attached survey. Upon opening the attached Microsoft Excel file, the recipient should have first noticed a detailed instruction page. This is been shown in Figure 3.

The respondent was first instructed to save the file as his or her name. Then, their name, discipline, office, and years experience should have been filled in completely before proceeding. After carefully reading the instructions, participants moved onto the following questions. Each module was separated into its own “tab” within Excel. Questions were answered by typing an “X” in the cell below the related number on the scale. This method of marking answers was followed for all evaluation criteria until each question from all three modules had been answered. A sample portion of a completed survey is shown in Figure 4.

SDE Development Program

Self Assessment Survey

Name: _____

Discipline: _____

Office: _____

Years Experience: _____

Instructions:

This survey has been developed as a means of measuring the success of the SDE Training Program. It has been constructed in three parts; Front End Planning, Project Execution, and Project Completion. These sections are found on separate tabs at the bottom of the screen, each representing a Module of the training program. This self assessment should only take about 30 minutes, but it is very important that you complete it frankly and honestly and then return it as the instructions indicate.

1 Save this file with your name as the title.
2 Fill in the name, discipline, office, and years experience information at the top of this page.
3 Review the following three tabs and place an "x" directly under the desired number for each question.
4 For each major heading in **bold**, indicate the level of implementation that has been seen since the conclusion of the course.
5 Save the file again once all questions have been answered, and return the survey via email.

Responses will be kept confidential. Personal information will only be used to assure that all participants have completed a survey. No documentation that comes from this data will contain names. Finally, the survey has been developed using this electronic format in an effort to reduce the amount of paper used. Please return this as soon as possible. Thank you.

Figure 3. Self-Assessment Survey Instruction Page.

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

Evaluation Criteria - General Knowledge	Level of Understanding: Pre-Training	Level of Understanding: Post-Training	Level of Implementation
Understanding Objectives			3
Understand that objectives are defined as the success criterion.	1	4	
Understand that there may be multiple alternatives that may satisfy the objectives for the project.	2	5	
Understand that project performance measures are not the same as project objectives.	1	4	
Understand that the phases of objectives setting include formation, communication, and integration.	3	5	
Understand the importance for objectives to be specific, identifiable, attainable, controllable, assignable, and realistic.	2	4	

Figure 4. Completed Portion of Self-Assessment Survey, Abridged.

This excerpt from the Front End Planning module, identical to that presented in chapter 4, illustrates how the Understanding Objectives portion of the survey was completed by the respondents. The level of implementation was scored for the session topic and the following questions were rated for both pre-training and post-training level of understanding. Once all sections of the survey were completed in a similar fashion, the file was once again saved so that it could be returned. The completed survey was then submitted via email to our research team for analysis. Overall, this method proved to be a somewhat simple solution to the challenge of minimizing the amount of paper used and eliminating the cost of postage.

Furthermore, the research team wanted to make sure that all respondents understood that this survey would merely be used as a method of measuring the effectiveness of the SDE Development Program. Responses were kept confidential. Any personal information required in the survey was used only for the purpose of keeping track of who had or had not completed the self-assessment form and possibly exploring how the responses varied between offices and/or disciplines.

Responses

Following the distribution of the SDE Development Program Self-Assessment Survey, responses were received over the course of a couple months. Some responded within a few days whereas others needed a follow-up email requesting them to complete the survey as soon as possible. Out of the 50y surveys distributed, a total of 38 responses were received. When the class participants were selected to attend the SDE skills development program, it was important that the engineers came from various disciplines throughout the industry. This became very apparent when the survey responses were reviewed. There seemed to be a fairly even distribution

of participants among the different engineering disciplines. Mechanical, structural, instrumentation and controls, piping, process, and electrical engineers were all well represented. Figure 5 shows the number of respondents representing each discipline.

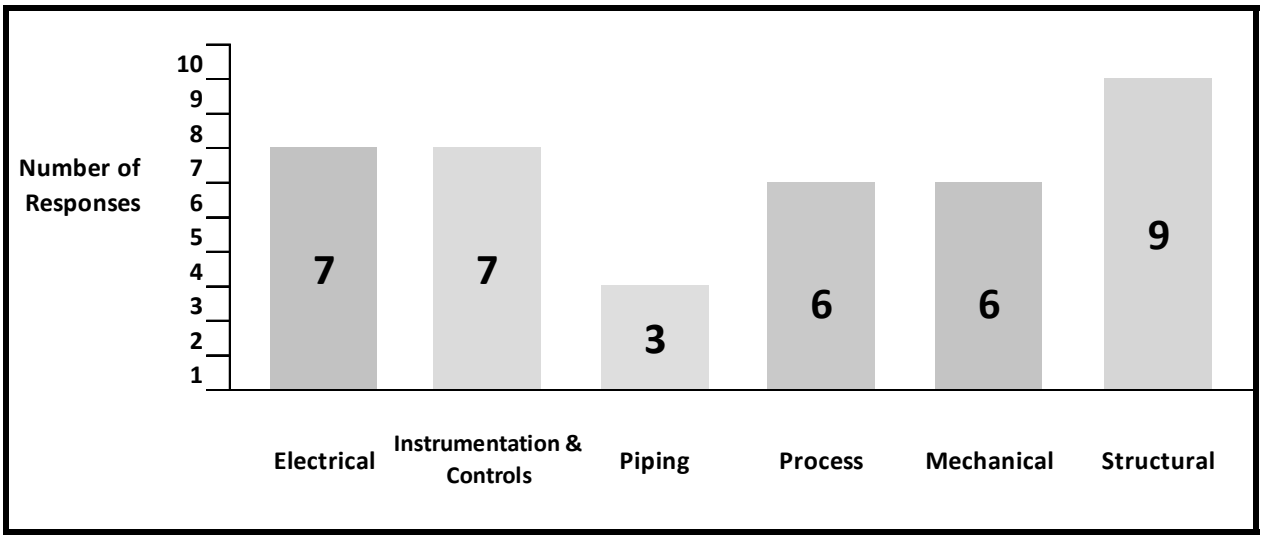

Figure 5. Number of Survey Responses by Engineering Discipline.

In addition to engineering discipline, responses were also unique based on the trainees' years of experience and office location. Some participants involved in the program had been working in their field for years whereas others may have had less experience. According to the 38 surveys received, experience ranged from 2 to 28 years. Also, the class participants were selected from numerous offices in major cities around the country. Participating engineers represented offices in Cleveland, Houston, Birmingham, Denver, and Princeton. The number of survey respondents from each of these cities is represented in Figure 6. The actual number of responses in this figure only equals 36 because of two unknown respondent office locations.

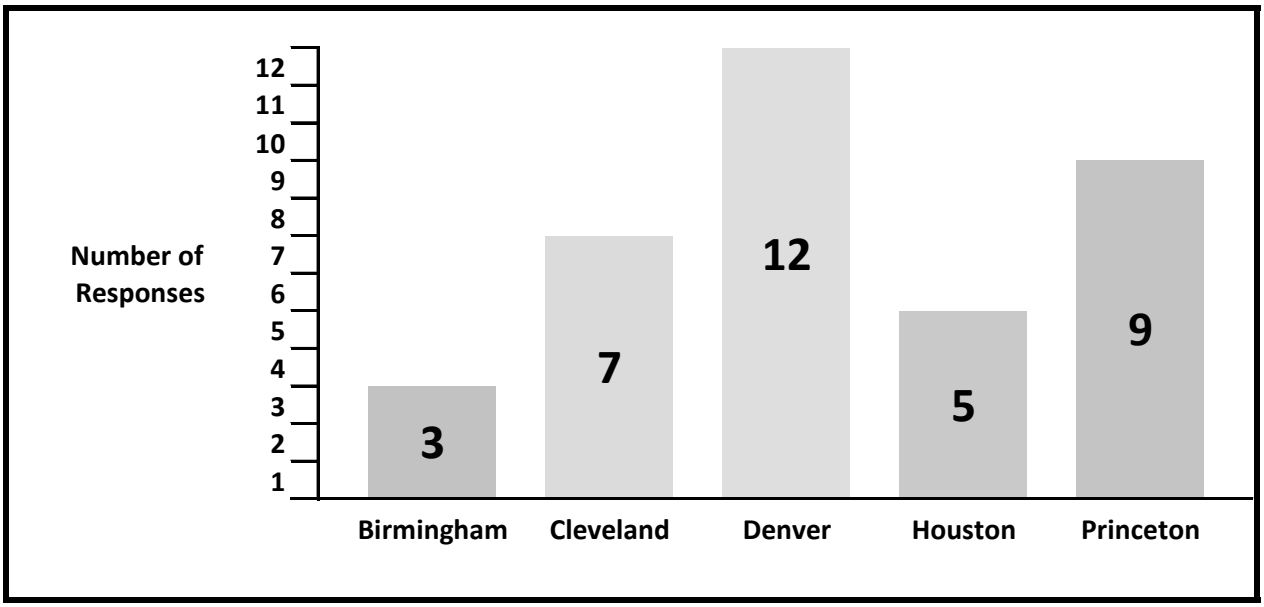

Figure 6. Number of Survey Responses by Office Location.

Although this grand total of 38 responses does not seem like a very large sample size, the methods used in this evaluation have allowed for a thorough measure of program effectiveness.

Data Organization

With the distributed self-assessment surveys completed and returned, all of the deliverables needed for an in-depth data analysis were accounted for. The first step in performing such an analysis required the development of a method for reviewing and organizing the data. In the case of the SDE Development Program Self-Assessment Survey, 38 respondents answered 104 questions, each with a numerical pre-training and post-training response. In addition, each survey required 22 numerical ratings of how well the learned skills have been implemented. With such a significant amount of numerical data needing to be analyzed, an efficient method for organizing this data was crucial. Finally, it was imperative that the organization method leave room for the addition of data from future SDE Development Programs.

The self-assessment survey data sheets were developed so that the SDEs' numerical answer could be recorded next to the corresponding question. Once again, a Microsoft Excel spreadsheet was used throughout the process. The result was a form that looked very similar to the actual survey. Two separate Excel worksheets were designated for each module: one for pre-training responses and one for post-training. Each SDE survey was given a number, eliminating the need for using the respondent's name. Upon reviewing the completed surveys, the pre-training and post-training numerical ratings were recorded under the SDE's number and next to the related question. This can perhaps be better understood by referring to the sample seen in Figure 7.

SDE Self Assessment Survey Data

Module 1 - Front End Planning

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

		Pre-Training				
	Evaluation Criteria - General Knowledge	SDE 1	SDE 2	SDE 3	SDE 4	SDE 5
Front End Planning	**Understanding Objectives**	-	-	-	-	-
	Understand that objectives are defined as the success criterion.	2	3	3	2	3
	Understand that there may be multiple alternatives that may satisfy the objectives for the project.	4	3	5	3	3
	Understand that project performance measures are not the same as project objectives.	3	2	5	3	3
	Understand that the phases of objectives setting include formation, communication, and integration.	2	1	4	2	2
	Understand the importance for objectives to be specific, identifiable, attainable, controllable, assignable, and realistic.	3	4	5	2	3

Figure 7. Sample Data Collection.

This is a portion of the pre-training responses from the Front End Planning module. An identical form is used to record the post-training responses. From this, the difference between pre-training and post-training can easily be calculated. Similarly, a list of the session topics was developed for the implementation responses (see Figure 8).

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

Evaluation Criteria	Level of Implementation				
	SDE 1	SDE 2	SDE 3	SDE 4	SDE 5
Understanding Objectives	4	3	4	2	4
Feasibility Phase	3	3	4	2	4
Concept Phase	2	3	4	2	4
Detailed Scope Phase	4	4	4	2	5
Contractual Relationships	2	3	2	1	1

Figure 8. Sample of Implementation Data.

This process of reviewing the surveys and transferring the numerical answers into a spreadsheet format was utilized for all 38 responses. A total of 37 responses have been used for analysis, as one was declared an outlier. Although the result was a fairly complex series of

spreadsheets, the organization of the data allowed for a manageable data analysis. The data compilations produced from the SDE Development Program Self-Assessment Survey provided a strong foundation for the task of measuring the training program's effectiveness. Each aspect of the program evaluation was based on the response data gathered from the SDE self-assessment surveys. A copy of the spreadsheet containing the individual survey responses is included in Appendix B. Details of the actual data analysis have been addressed in the following chapter.

CHAPTER 6

DATA ANALYSIS

Introduction

Even before the self-assessment surveys were distributed, the research team had a vision of what the resulting data should produce. For the SDE Development Program to be considered a success, the responses had to indicate that a substantial amount of change had taken place. The engineers' general knowledge of the evaluation criteria needed to show considerable improvement over the course of the skills development program. Ideally, pre-training ratings would have typically ranged from 1 to 3 and post-training ratings would have shown a shift into the 3 to 5 range. If this theory did not prove true, then there were substantial problems occurring throughout the teaching and/or learning process. With the organization of the data complete, a meticulous evaluation of the data provided an answer to the most important question. Was the program successful in bringing about the desired change?

Level of Understanding Analysis

Although this data analysis was performed in an effort to draw a single conclusion regarding the effectiveness of the SDE Development Program, there were several ways in which to present the statistical results. Because of the manner in which the self-assessment survey data was organized, the research team was able to analyze each module individually. From this analysis, the results have been illustrated utilizing various numerical and graphical representations.

The first step in the analysis process was examining the numerical responses for each module and calculating the average rating for each question. This was completed within the prepared Microsoft Excel spreadsheets, which were described in the previous chapter. With each SDE's numerical response entered into the spreadsheet next to the corresponding evaluation criteria, an average pre-training and post-training response for each question was calculated. The calculated average rating are displayed in the scatter plots below. Figures 9, 10, and 11 represent the average rating of evaluation criteria for each individual module.

Figure 9 illustrates the average response for each individual evaluation criterion within the Front End Planning section of the survey.

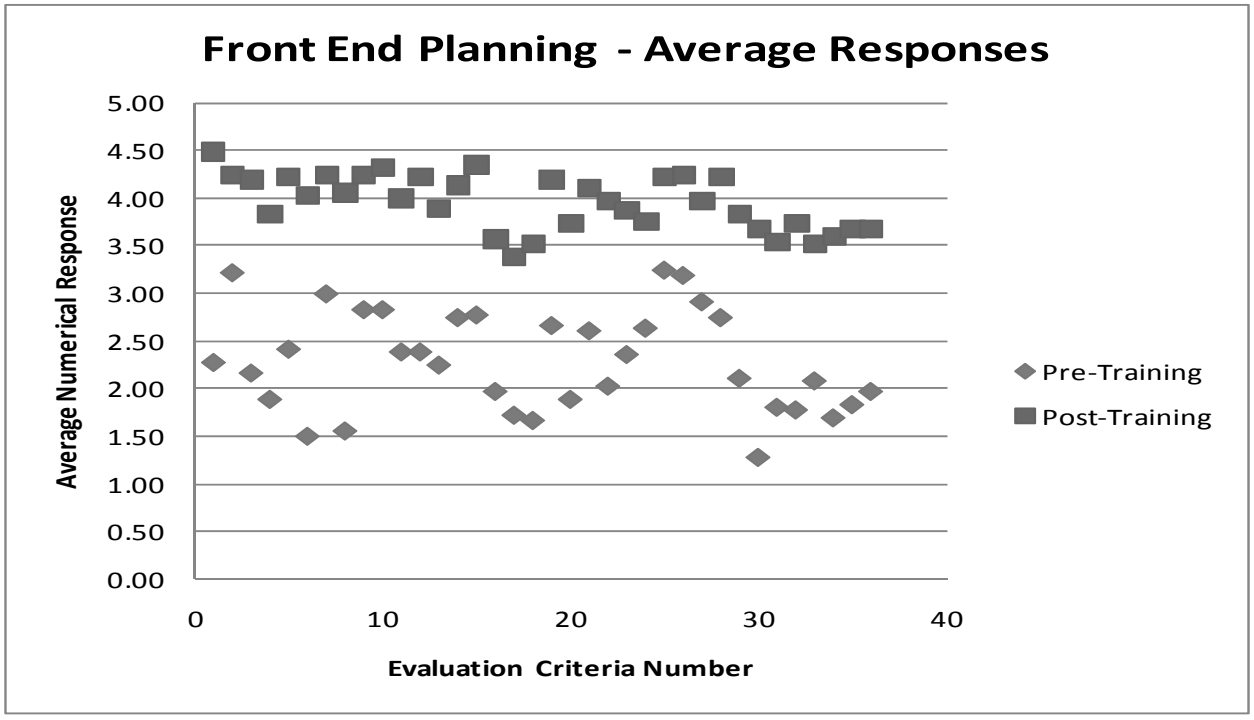

Figure 9. Average Responses from the Front End Planning Module.

Similarly, Figure 10 represents the average evaluation criteria ratings from the Project Execution module.

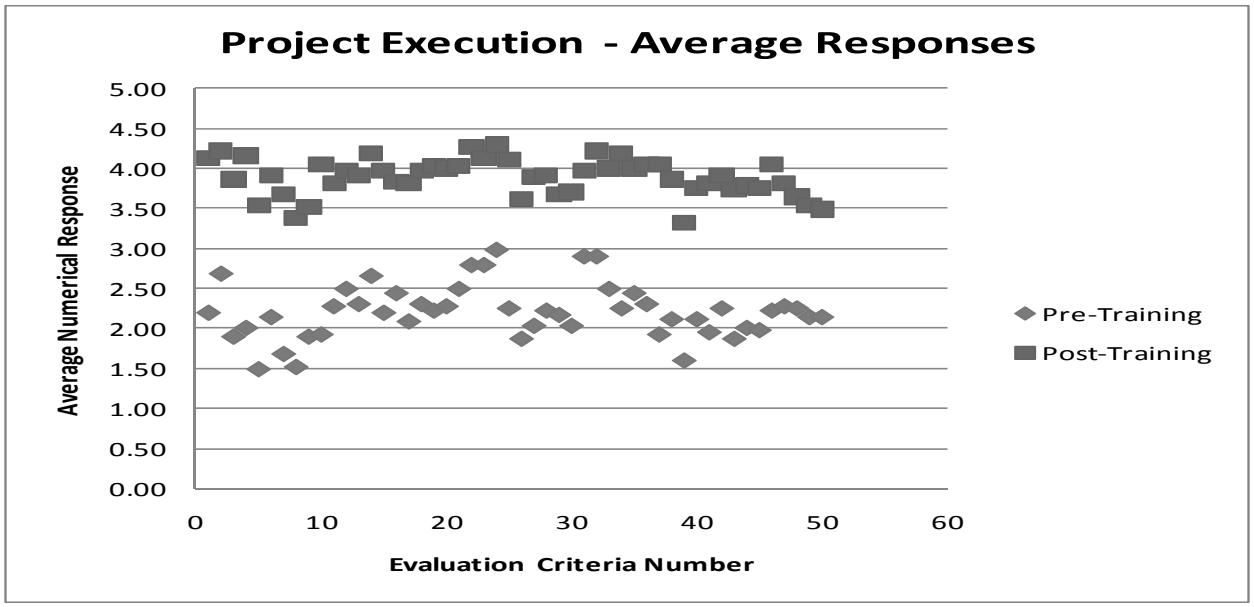

Figure 10. Average Responses from the Project Execution Module.

Finally, Figure 11 uses the same scatter plot distribution to illustrate the responses to the Project Completion evaluation criteria.

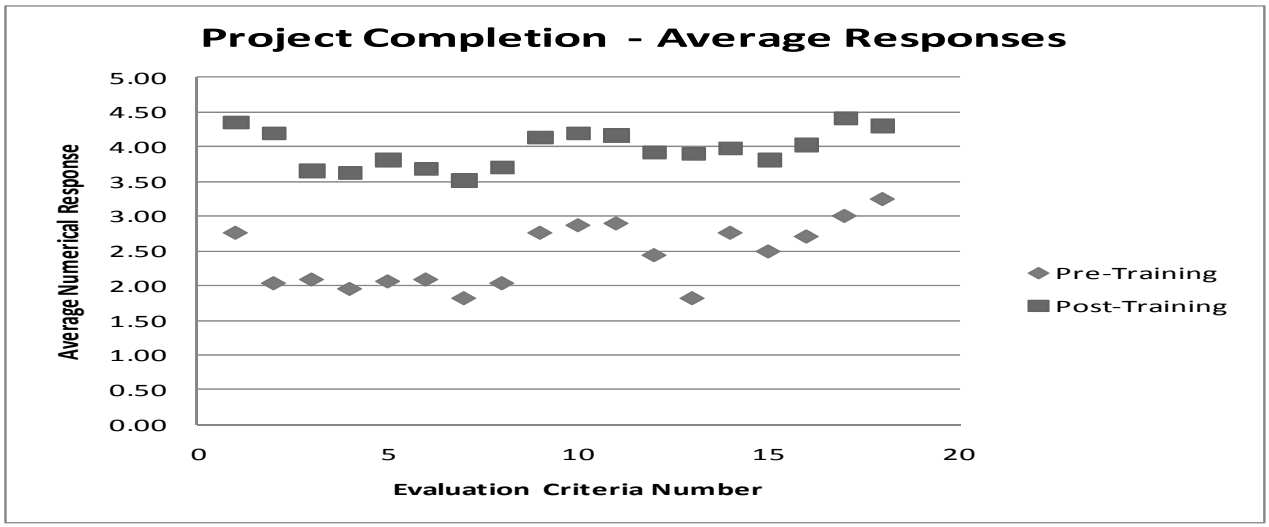

Figure 11. Average Responses from the Project Completion Module.

As stated previously, the average numerical responses were based upon a rating scale of 1 to 5, with 1 being *little* and 5 being *proficient or expert*. These scatter plots indicate that the numerical range of pre-training and post-training responses remained fairly consistent among the three separate modules. In addition, the average post-training responses were noticeably higher than those ratings of knowledge prior to training. This visible distinction between data sets was a very good sign that change had taken place.

Furthermore, percentages have also been used to illustrate the distribution of responses. These percentages were calculated by dividing the frequency of each numerical response by the total number of survey responses. Once again, this was done for both pre-training and post-training to allow for comparison. Just like the graphical representation mentioned previously, this analysis showed a significant difference between pre and post-training. For example, the sample shown in Figure 12 examines the percentage of responses from the Concept Phase session of the Front End Planning module.

Prior to the training, rating percentages generally remained fairly low. The majority of answers stayed within the 1 to 3 range. However, the post-training percentages, shown on the right side of the figure, reveal minimal ratings in the range between 1 and 2. For this to be the case, the training must have had some significant impact on the discipline engineers attending the program. With this in mind, a numerical representation of the change brought on by the skills development program was able to be calculated.

SDE Self Assessment Survey

Module 1 - Front End Planning

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

Evaluation Criteria - General Knowledge	Percentage - Pre-Training					Percentage - Post-Training				
	Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5	Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5
Concept Phase	.	.	.	.	.	.	.	.	.	.
Understand the importance of validating all assumptions generated in the feasibility phase.	11%	30%	35%	24%	0%	0%	0%	19%	49%	32%
Understand the content and importance of the design basis document.	19%	27%	22%	24%	8%	0%	0%	5%	54%	41%
Understand how to structure a successful analysis of project alternatives.	41%	30%	24%	5%	0%	0%	5%	41%	46%	8%
Understand how to differentiate between conceptual and preliminary estimating techniques.	46%	38%	14%	3%	0%	3%	14%	38%	35%	11%
Understand how to evaluate progress during the execution of Front End Planning.	51%	35%	11%	3%	0%	0%	8%	41%	43%	8%

Figure 12. Data Distribution: Percentages.

The amount of change in level of understanding that took place during the SDE Development Program was calculated in a fairly simple manner. By subtracting the pre-training rating from the post-training rating, the change was calculated for every question from each respondent's self-assessment survey. The resulting averages were extremely consistent among the three modules. Both the Front End Planning and Project Execution modules showed an average change of 1.7 points. Following close behind, the Project Completion and Team Dynamics generated an average change of 1.6 points. Once again, this numerical change is based on the scale of 1 to 5. While 1.7 and 1.6 do not seem like astonishing numbers, they do indicate that considerable learning has taken place. The resulting data suggests that the responses have generally moved from the range of *little* and *some* to a range of *much* and *proficient*. This is not to say that there is no room for improvement. In a perfect situation, all of the engineers entering

with minimal knowledge of the program material would leave as experts on the subject. However, perfection is difficult to achieve during a 10-day skills development program that covers such a vast amount of material. Overall, the skills introduced during the program were well received and it can be said that a positive change in the participants' level of understanding has occurred.

While computing the average change did indicate that a transformation had taken place, the three calculated values did not adequately represent the significance of this change. Hence, the research team then decided that perhaps a better way to illustrate the level of program effectiveness was with a graphical representation of the data distribution. The Central Limit Theorem states that random samples of a certain number of observations that are taken from any population will produce a distribution of the sample means that is approximately normal (Groebner & Shannon, 1993). As a rule of thumb, the number of observations should be greater than or equal to 30. In the case of the SDE Development program, the engineering participants represent the random sample. The 38 survey responses met the sample size criteria and thus should have produced a normal distribution of the answer means.

Although the averages indicated a shift in level of understanding between pre-training and post-training, the amount of variance within the data had to be calculated in order to verify the accuracy of this numerical change. Using the Minitab 15 statistical software program, a histogram graph was used to represent the distribution of evaluation criteria responses for Modules One, Two, and Three. As stated in the Central Limit Theorem, the averages of the response data resulted in distributions that were approximately normal. In the following three figures, each graph displays two curves; one representing pre-training response distribution and another representing that of post-training responses.

In Figure 13, the response distribution for the Front End Planning Module is illustrated. Notice the difference between the pre-training and post-training distributions.

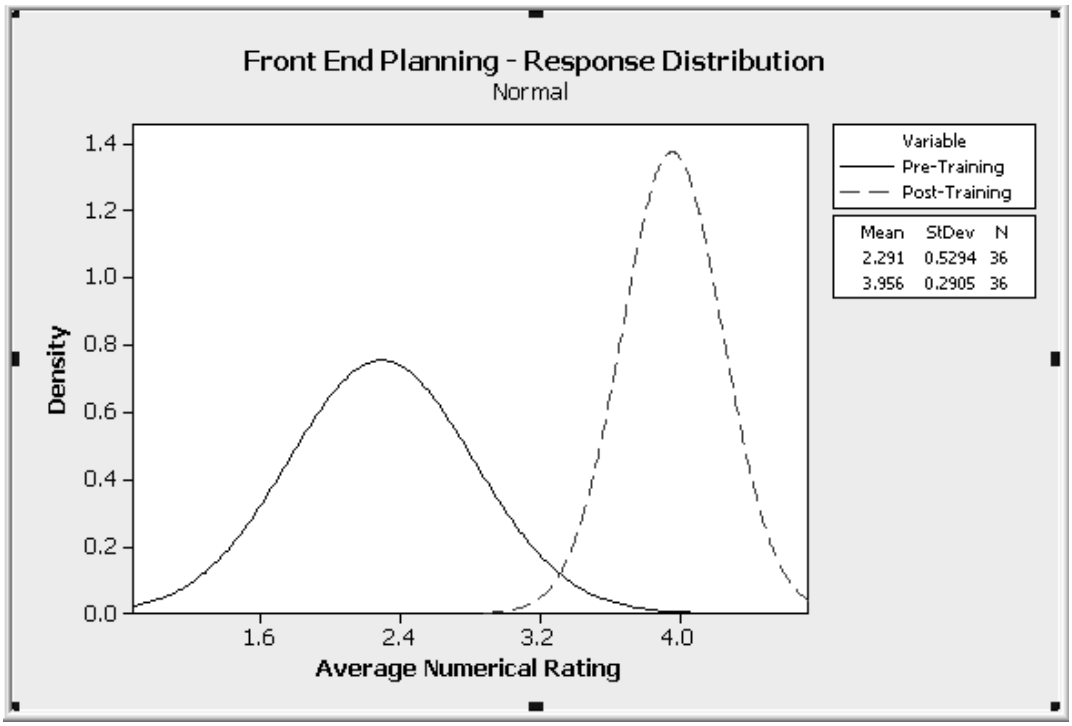

Figure 13. Response Distribution from the Front End Planning Module.

Similarly, a significant difference between the distributions was seen in the Project Execution module, illustrated in Figure 14.

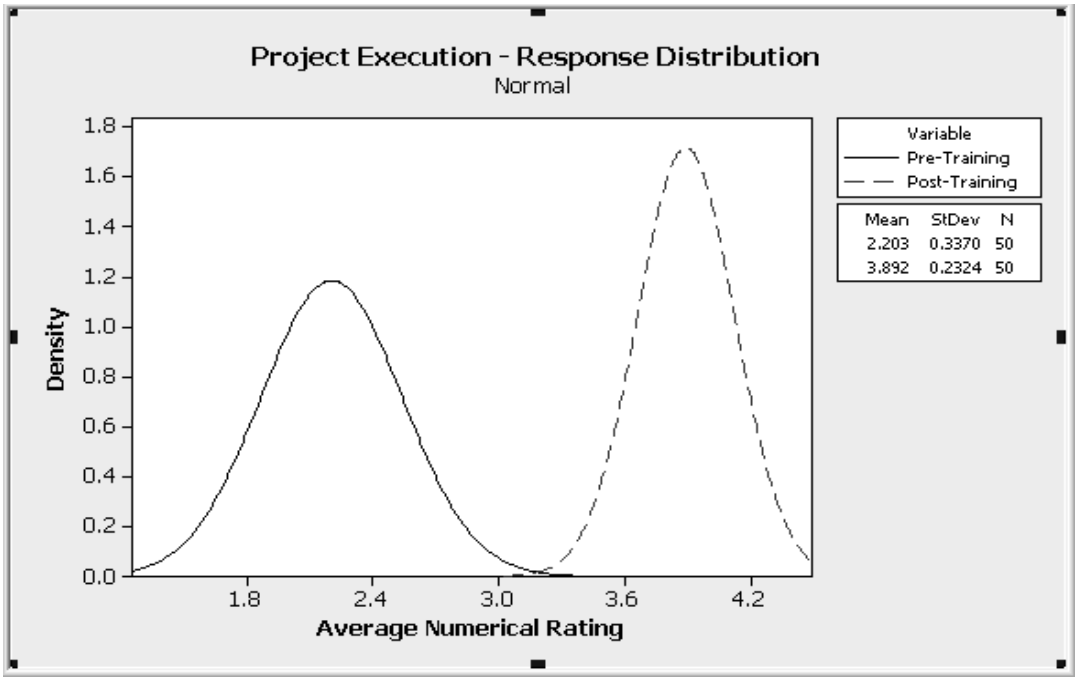

Figure 14. Response Distribution from the Project Execution Module.

Finally, the distributions generated from the Project Completion module closely resembled those from the previous two modules.

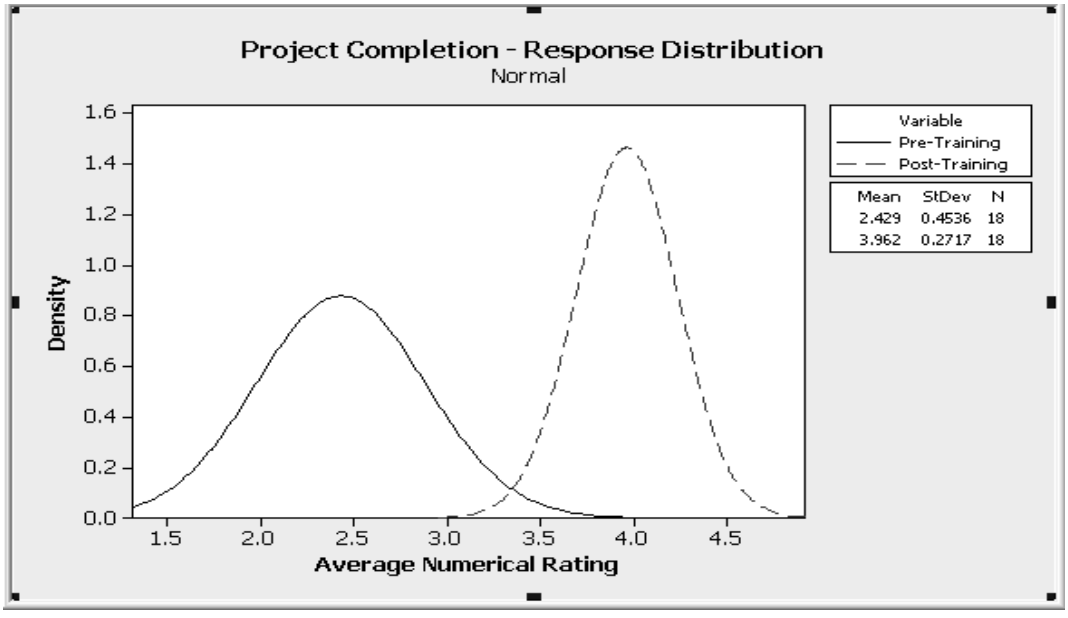

Figure 15. Response Distribution from the Project Completion Module.

Within the data distributions, a significant shift in the average rating is apparent. It should also be noted that the standard deviation of the pre-training responses was slightly larger than that of the post-training responses. This was largely due to the engineers' various levels of experience and knowledge prior to the SDE Development Program. In addition, the smaller standard of deviation among the post-training distributions suggested that the program participants have gained a better sense of alignment regarding knowledge of the course material. It must be noted that comparing averages, as was the case in this distribution analysis, often results in misleading data. However, based on the consistency of the survey data and the low standard deviation, the comparison of average answer distributions that has been made does portray the change in knowledge very well.

In an effort to verify the data shift seen previously, the research team performed a more in-depth analysis of the evaluation criteria responses. Here, a histogram was produced using the frequency of the answers for individual questions in the survey. Comparing the distribution of numerical ratings between pre-training and post-training responses can more accurately display the magnitude of the change that has occurred. Using the Minitab 15 statistical software program, all 37 SDE's pre-training and post-training ratings for a particular question were inserted into the spreadsheet. Then, a single histogram was produced which displayed both the pre-training and post-training distribution of responses for that question. Finally, in order to create a more effective visual representation of the histogram, a curve was fit to the data. It must be noted that each of the curves appear to be normal distribution curves. However, this does not imply that the distribution of each response is precisely normal. The curves have simply been used as an illustration of the shift in response data. The following graphs are several examples of

those produced to analyze the level of understanding regarding the evaluation criteria within the SDE Development Program self-assessment survey.

Figure 16 illustrates the distribution of responses for Evaluation Criteria A-6. Both the pre-training and post-training distributions have been presented, as well as the mean and standard deviation of each. In this scenario, notice how the post-training mean has shifted significantly to the right and how the standard deviations are very similar.

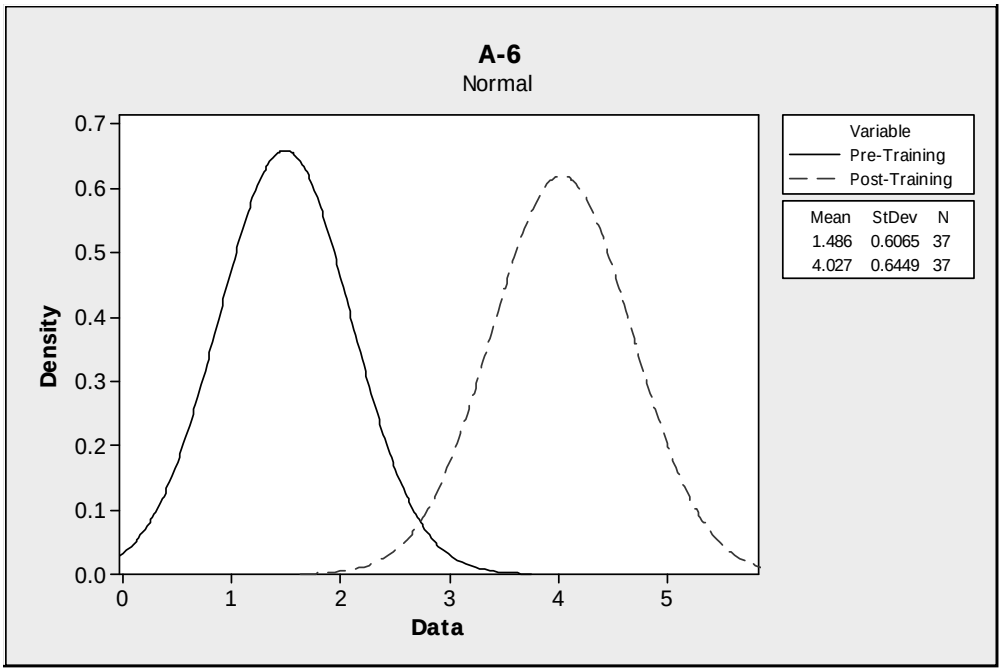

Figure 16. Distribution of Responses for Evaluation Criteria A-6.

- Evaluation Criteria A-6: Understand that the three dimensions of alignment include organizational hierarchy, multi-organizational boundaries, and the project life cycle.
- Difference Between Pre-Training and Post-Training Means: 2.5
- Pre-Training Standard Deviation: 0.61
- Post-Training Standard Deviation: 0.64

- The standard deviations of the curves were very similar. This indicated that the participants' knowledge of this material was fairly aligned both pre-training and post-training. Also, a very substantial improvement in level of understanding has occurred.

Similarly, Figure 17 illustrates the distribution of responses for Evaluation Criteria C-3. Here it should be noted that another scenario shows a standard deviation that is significantly larger in the pre-training distribution.

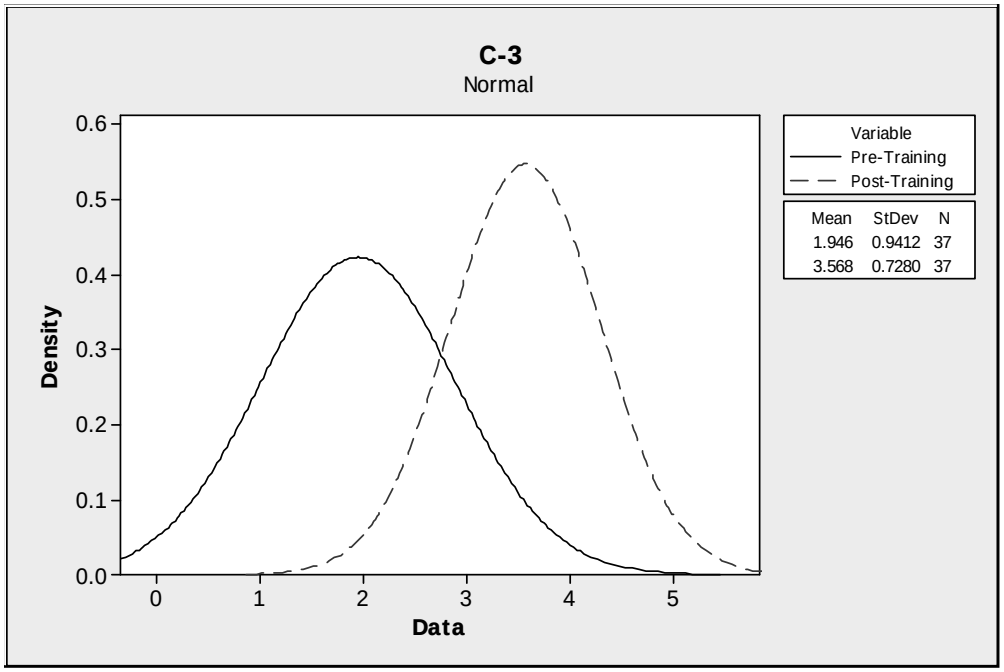

Figure 17. Distribution of Responses for Evaluation Criteria C-3.

- Evaluation Criteria C-3: Understand how to structure a successful analysis of project alternatives.
- Difference Between Pre-Training and Post-Training Means: 1.7
- Pre-Training Standard Deviation: 0.94
- Post-Training Standard Deviation: 0.73

- The standard deviation among the pre-training data was larger than that of the post-training responses. This suggested that the level of knowledge regarding this evaluation criterion varied among the engineers prior to training. However, a much greater and substantially more aligned understanding of this information was gained through the course of the skills development program.

Another scenario can be seen in Figure 18. Unlike the previous two scenarios, Evaluation Criteria G-3 saw a much larger standard deviation in the post-training distribution of responses.

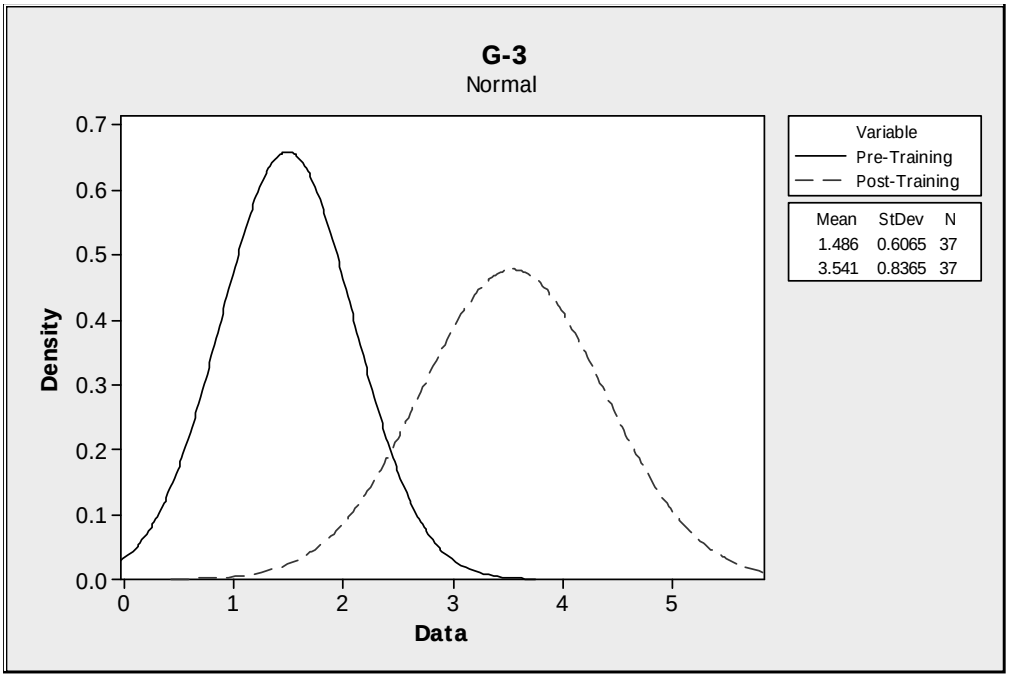

Figure 18. Distribution of Responses for Evaluation Criteria G-3.

- Evaluation Criteria G-3: Understand the importance of the risk category guidelines found in the Project Execution Procedures.
- Difference Between Pre-Training and Post-Training Means: 2.0
- Pre-Training Standard Deviation: 0.61

- Post-Training Standard Deviation: 0.84
- Here, a much lower standard deviation was present within the pre-training responses. Participants seemed to consistently enter the program with a low level of understanding. Although the average response did increase by two points, the post-training knowledge pertaining to this topic was widely distributed and lacked a sense of alignment.

The distribution of responses for Evaluation Criteria J-3 is seen in Figure 19. Like the second example, the standard deviation is much less in the post-training distribution.

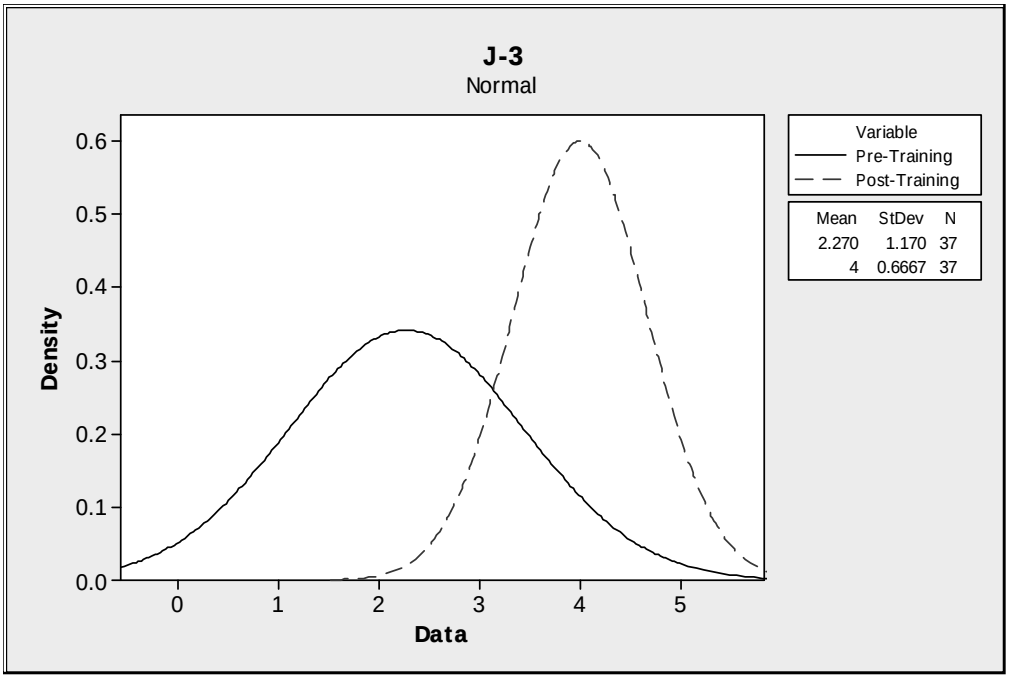

Figure 19. Distribution of Responses for Evaluation Criteria J-3.

- Evaluation Criteria J-3: Understand the constructability process and its benefit to the project.
- Difference Between Pre-Training and Post-Training Means: 1.7

- Pre-Training Standard Deviation: 1.17
- Post-Training Standard Deviation: 0.67
- The difference in the means for this criterion was right at the average of 1.7, as it was calculated previously. The lower post-training standard deviation suggested alignment among the engineers' knowledge and represents a much more significant level of change in understanding.

Similar to the previous example, Figure 20 represents the distribution of responses for Evaluation Criteria O-1.

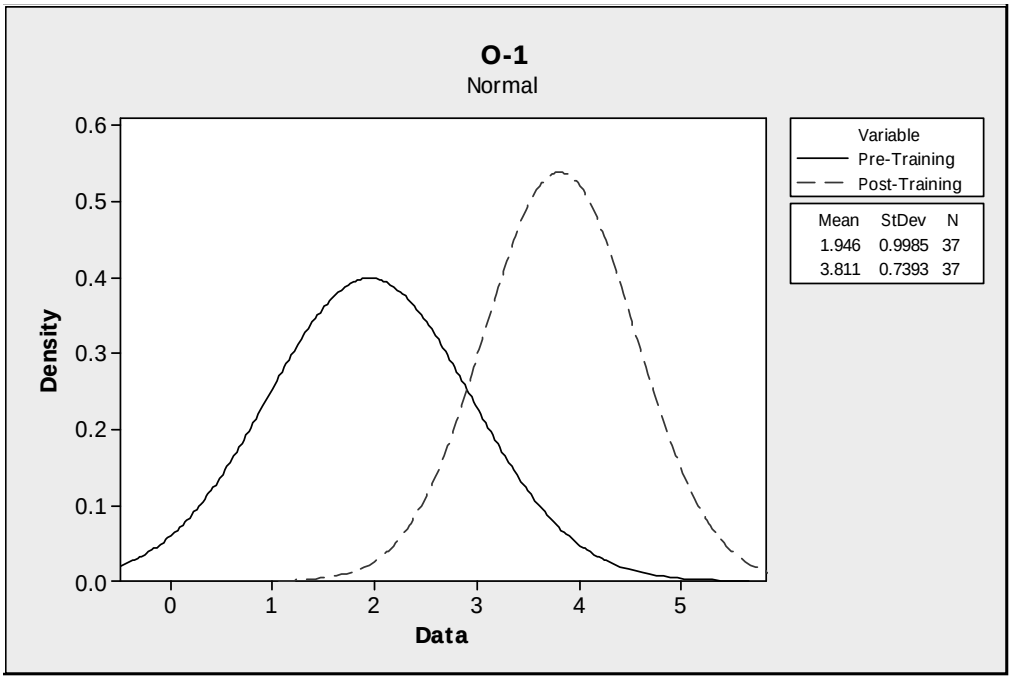

Figure 20. Distribution of Responses for Evaluation Criteria O-1.

- Evaluation Criteria O-1: Understand the process to calculate performance indices (PIs) and schedule performance indices (SPIs).
- Difference Between Pre-Training and Post-Training Means: 1.9

- Pre-Training Standard Deviation: 1.00
- Post-Training Standard Deviation: 0.74
- The results here were very similar to those found in the previous example. The alignment of post-training responses was much better than that of the pre-training responses.

Finally, distributions for Evaluation Criteria R-2 are represented in Figure 21.

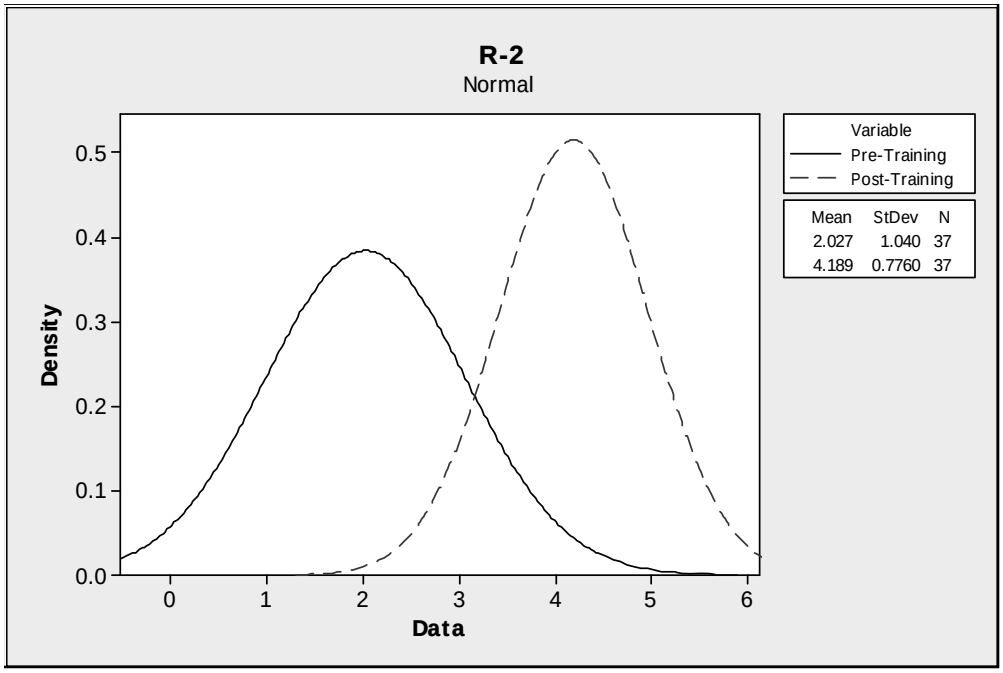

Figure 21. Distribution of Responses for Evaluation Criteria R-2.

- Evaluation Criteria R-2: Understand the importance of initiating start-up planning during the FEP process.
- Difference Between Pre-Training and Post-Training Means: 2.2
- Pre-Training Standard Deviation: 1.04
- Post-Training Standard Deviation: 0.78

- Once again, the pre-training distribution of ratings had a standard deviation that was much larger than the post-training distribution. This seemed to be a trend among the evaluation criterion and was a good sign that significant learning had taken place.

It is important to understand that the information covered in the course material was not the focus of this analysis. For this reason, the stated evaluation criterion in each example was simply given as a reference and has not been explained in detail. The main focus was measuring the effectiveness of the program as a whole. Keeping this in mind, the answer distributions were then examined and it was determined how the data represented the effectiveness of the program as a whole.

As seen in the previous examples, the analysis of the individual evaluation criterion produced three different scenarios:

1. The pre-training response distribution had a smaller standard deviation.
2. The pre-training and post-training standard deviations were about the same.
3. The post-training response distribution had a smaller standard deviation.

In most cases, the mean post-training scores had shifted noticeably from the left side of the scale to the right side indicating a considerable improvement in the participants' level of understanding in the particular subject. However, the significance of this shift depends on the alignment of responses. Alignment in this sense refers to the minimal variation of answers among the SDE Development Program participants, or standard deviation. The overall goal was for the standard deviation of the data distributions to be relatively small in the post-training responses. Scenarios 2 and 3 both met this condition. In both situations, the standard deviation of post-training responses was comparatively low, suggesting a sense of alignment among the engineers' improved level of understanding. As it turns out, the majority of the evaluation

criteria responses fell into either Scenario 2 or Scenario 3, where the post-training response distributions had a much smaller standard deviation than that of the pre-training answers. A graph showing the distribution of answers was created for each question in the SDE Development Program self-assessment survey. Among the 104 graphs, only 7 of them revealed a significantly larger standard deviation in the pre-training responses compared to that of the post-training data.

Table 3

Total Number of Each Distribution Scenario

	Scenario	Total
1	The pre-training response distribution had a smaller standard deviation.	7 out of 104
2	The pre-training and post-training standard deviations were about the same	9 out of 104
3	The post-training response distribution had a smaller standard deviation.	88 out of 104

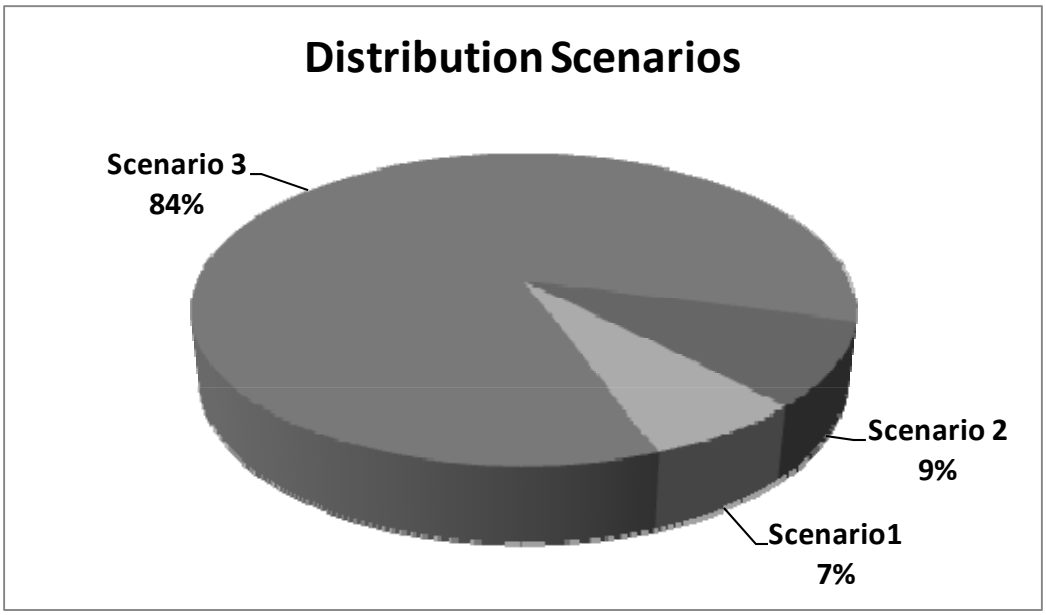

Figure 22. Percentage of Each Distribution Scenario.

Even in these few examples that fell into the Scenario 1 type of graph, the engineers had made a considerable improvement in their understanding of the material; the results gathered were just less significant.

The distribution of responses for all 104 evaluation criterion has been included in Appendix D. However, a summary of the data gathered from these distributions can be seen below in Table 4. The mean, mode, and standard deviation of the evaluation criteria response distributions has been included in this table to further illustrate the difference between pre-training and post-training responses.

Table 4

Summary of Data from Evaluation Criteria Response Distributions

Evaluation Criteria	Mean		Mode		Standard Deviation	
	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training
A1	2.24	4.49	2	5	0.86	.061
A2	3.19	4.24	3	4	0.97	0.72
A3	2.16	4.19	2	4	0.96	0.66
A4	1.87	3.84	1	4	1.03	0.76
A5	2.41	4.22	2	4	0.96	0.79
A6	1.49	4.03	1	4	0.61	0.64
A7	2.97	4.24	3	4	0.96	0.64
A8	1.57	4.05	1	4	0.73	0.74
B1	2.78	4.24	3	4	1.03	0.64
B2	2.78	4.32	3	4	0.95	0.67
B3	2.35	4.00	2	4	1.11	0.75
B4	2.35	4.22	2	4	1.14	0.67
B5	2.22	3.89	2	4	0.89	0.66
C1	2.73	4.14	3	4	0.96	0.71
C2	2.76	4.35	2	4	1.26	0.59
C3	1.95	3.57	1	4	0.94	0.73
C4	1.73	3.38	1	3	0.80	0.95
C5	1.65	3.51	1	4	0.79	0.77
D1	2.65	4.19	2	4	0.98	0.62
D2	1.86	3.73	2	4	0.79	0.73

(*table continues*)

Evaluation Criteria	Mean		Mode		Standard Deviation	
	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training
D3	2.59	4.11	3	4	1.07	0.81
D4	2.00	3.97	1	4	1.05	0.93
D5	2.35	3.86	3	4	1.01	0.79
D6	2.62	3.76	3	4	1.06	0.68
D7	3.22	4.22	3	4	0.95	0.67
D8	3.16	4.24	3	4	1.09	0.68
D9	2.89	3.97	3	4	0.91	0.60
D10	2.76	4.22	2	4	1.09	0.53
D11	2.11	3.84	1	4	1.05	0.69
D12	1.27	3.68	1	4	0.77	0.82
E1	1.84	3.54	2	4	0.76	0.65
E2	1.78	3.73	2	4	0.67	0.73
E3	2.08	3.51	2	4	0.95	0.65
E4	1.70	3.59	1	4	0.85	0.83
E5	1.84	3.68	1	4	0.87	0.71
E6	1.97	3.68	2	4	0.83	0.71
F1	2.19	4.14	2	4	0.88	0.71
F2	2.68	4.22	2	4	1.00	0.75
G1	1.89	3.86	2	4	0.94	0.67
G2	2.00	4.16	2	4	1.13	0.69
G3	1.49	3.54	1	4	0.61	0.84
G4	2.14	3.92	1	4	1.13	0.76
G5	1.68	3.68	1	4	0.78	0.71
H1	1.51	3.38	1	4	0.65	0.68
H2	1.89	3.51	2	4	0.91	0.69
H3	1.92	4.05	1	4	1.12	0.70
H4	2.27	3.81	2	4	1.19	0.74
H5	2.49	3.97	3	4	1.17	0.76
I1	2.30	3.92	2	4	0.94	0.72
I2	2.65	4.19	3	4	0.98	0.66
I3	2.19	3.97	2	4	1.05	0.76
I4	2.43	3.84	2	4	1.24	0.80
I5	2.08	3.81	2	4	0.86	0.70
J1	2.30	3.97	2	4	1.10	0.87
J2	2.22	4.03	1	4	1.16	0.76
J3	2.27	4.00	2	4	1.17	0.67
J4	2.49	4.03	1	4	1.33	0.76
K1	2.78	4.27	3	4	1.08	0.61
K2	2.78	4.14	3	4	1.27	0.79
K3	2.97	4.30	3	4	1.17	0.78
L1	2.24	4.11	2	4	1.01	0.70

(*table continues*)

Evaluation Criteria	Mean		Mode		Standard Deviation	
	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training
L2	1.86	3.62	1	4	0.95	0.59
L3	2.03	3.89	1	4	0.93	0.74
M1	2.22	3.92	2	4	1.03	0.80
M2	2.16	3.68	2	4	0.90	0.75
M3	2.03	3.70	2	4	0.80	0.81
M4	2.89	3.97	3	4	1.02	0.69
M5	2.89	4.22	3	4	0.99	0.75
N1	2.49	4.00	2	4	1.24	0.67
N2	2.24	4.19	1	4	1.06	0.57
N3	2.43	4.00	2	4	1.17	0.67
N4	2.30	4.05	2	4	1.20	0.70
N5	1.92	4.05	1	4	1.19	0.70
N6	2.11	3.86	2	4	1.07	0.79
N7	1.59	3.32	1	4	0.80	0.82
N8	2.11	3.76	2	4	0.88	0.68
O1	1.95	3.81	1	4	1.00	0.74
O2	2.24	3.92	2	4	1.14	0.72
O3	1.86	3.73	1	4	1.06	0.87
P1	2.00	3.78	1	4	0.88	0.71
P2	1.97	3.76	2	4	0.93	0.64
P3	2.22	4.05	2	4	1.16	0.62
Q1	2.27	3.81	2	4	0.90	0.88
Q2	2.24	3.65	2	4	0.93	0.86
Q3	2.14	3.54	2	4	0.75	0.87
Q4	2.14	3.49	2	3	0.79	0.84
R1	2.76	4.35	3	5	0.98	0.68
R2	2.03	4.19	1	4	1.04	0.78
R3	2.08	3.65	2	3	0.89	0.92
R4	1.95	3.62	1	4	1.08	0.79
R5	2.05	3.81	2	4	0.88	0.88
R6	2.08	3.68	2	3	0.98	0.97
S1	1.81	3.51	1	3	0.91	0.65
S2	2.03	3.70	2	4	1.07	0.70
T1	2.76	4.14	3	4	0.93	0.71
T2	2.86	4.19	3	4	0.82	0.62
T3	2.89	4.16	3	4	1.20	0.80
T4	2.43	3.92	2	4	.099	0.80
T5	1.81	3.89	1	4	0.97	0.81
U1	2.76	3.97	3	4	1.01	0.76
U2	2.49	3.81	2	4	1.02	0.74
U3	2.70	4.03	3	4	0.88	0.80

(*table continues*)

Evaluation Criteria	Mean		Mode		Standard Deviation	
	Pre-Training	Post-Training	Pre-Training	Post-Training	Pre-Training	Post-Training
V1	3.00	4.41	2	4	1.18	0.60
V2	3.24	4.30	3	4	1.14	0.62

After completing this distribution analysis, it was apparent by examining the graphs and the summary of results that a noteworthy change had taken place in the knowledge of the participants regarding every single evaluation criterion in the self-assessment survey. Among all of the ways that the survey data was analyzed, this analysis of individual evaluation criteria turned out to be the most powerful by far. It has become apparent that the SDE Development Program was successful in bringing about a substantial transformation in the participating engineers' knowledge of the program material and their ability to perform the learned skills.

Implementation Analysis

The second aspect of this data analysis focuses on the level of implementation that has occurred in the engineers' workplace. From our experience, it seems that there were two major issues that prevented adequate implementation from occurring. First, it was possible that a trainee may completely understand the material and learn the necessary skills, but management holds them back. Success in training requires cooperation from supervisors and upper management. If they are not open to the new ideas and skills learned during the training program, implementation cannot successfully occur. On the other hand, it was possible that the employees involved in the program have learned the training material but not well enough to implement it. In either case, steps must be taken to allow for an easy transition from training back into the

work environment. Without implementation, training adds minimal value to the company providing the program.

Along with measuring the change in level of understanding, the SDE Self-Assessment Survey asked the class participants to rate this level of implementation to the best of their ability. All 22 topics were rated on the scale of 1 to 5 based on how well the skills introduced in each session had been utilized on the job. After reviewing all of the surveys and recording the responses, an average was calculated. The compilation of data generated an average level of implementation of 3.0. Given the short period of time between training completion and the distribution of the survey, this is rather impressive. However, upon further investigation, the data reveals an extremely large standard deviation. In comparison to the previous analysis of trainee knowledge, responses in this portion of the survey were all over the board. Yes, the average was 3, but this was not necessarily a trend. In fact, each session saw ratings vary from 1 to 5. For this reason, it would be inaccurate to state that the majority of SDEs have seen an "average" level of implementation relating to the skills learned throughout the sessions of the program. Even though the average response was around 3 when looking at either individual SDEs or individual questions, the lack of a trend greatly takes away from the value of this statistic.

The lack of a trend seen in the implementation analysis could be due to the project nature of URS Washington Division's business. Each project is managed differently. Following the conclusion of the program, each SDE participant went back to various projects with different management teams and different attitudes towards the SDE Development Program material. One of the purposes of the program was to use the SDEs to help change the culture of the company.

Nevertheless, due to the variation in the data distribution, it is difficult to say that these findings are of similar significance to those in the previous level of understanding analysis. It

seems that level of implementation would best be evaluated by the trainees' superiors. Supervisors and upper management could provide an outside point of view needed to perform an accurate evaluation of implementation. Such a measurement should be conducted in the future in order to satisfy the next level of evaluation regarding the long-term influence of the training.

Summary

Although the implementation analysis did not generate the results that were initially expected, the self-assessment survey was successful in performing a valuable evaluation of the SDE Development Program as a whole. The training program was designed to provide discipline engineers with the skills needed to move into the Supervising Discipline Engineer role. Leadership, management, and teambuilding skills are crucial in such a role. The self-assessment survey was developed to measure how well the information was learned. According to the resulting data, the SDE training program was successful in bringing about change. The difference between pre-training and post-training knowledge is a clear indicator that a statistically significant change in understanding has taken place. In the introduction of this chapter, a simple question was asked: "Was the program successful in bringing about the desired change?" Based on the data collected from the self-assessment surveys, yes it was.

CHAPTER 7

CONCLUSION

Limitations

As stated previously, the SDE Development Program has been completed only twice. With only about 50 trainees participating in the program thus far, the data used in this research is based on a relatively small sample size. Unfortunately, a smaller sample size created limitations on the amount of detail used in the data analysis. On the instruction sheet for the self-assessment survey, respondents were required to provide their office location, discipline, and years of experience. A larger sample size would allow for the data to be analyzed based on each of these three classifications. For example, the evaluation would be able to determine whether the program was better received by mechanical engineers in comparison to the other disciplines. By doing this, it would be possible to determine whether there was a statistical difference in the responses based on the engineers' discipline, office location, and/or experience. The 38 responses included in this analysis did not represent a large enough sample to perform this detailed of an analysis. However, if the SDE Development Program continues to run and more evaluations are received, the same self-assessment survey can be used to perform a much more in-depth analysis of the data.

Closing Remarks

As stated previously, very little literature seems to have been written on this specific issue of training design professionals. Engineers work in a complex environment where time is

of great value. A successful training program must allow employees to learn the desired skills in a compressed amount of time. However, they must master these skills well enough that they may be transferred and utilized in their everyday work environment. For this reason, the details of program development and effectiveness measurement are crucial. This was also the case for URS Washington Division's SDE Development Program. While the program itself was developed using a format very familiar to the instructor, the method of measuring the effectiveness was somewhat of a challenge. The unique nature of discipline engineering training programs makes it difficult to develop a universal method of evaluation. Such programs differ greatly by means of both content and delivery method. Following the SDE training program, our research team worked to develop an adequate method to measure effectiveness. Beginning with a blank spreadsheet and a list of evaluation criteria, the SDE Self-Assessment Survey took shape and proved to be an effective way to measure the learning that took place during the skills development program. In the end, our research team discovered that the transformation that occurred through training is significant. The objectives of program development, delivery, and evaluation were successfully achieved. At the conclusion of the program, participating engineers had been introduced to skills that have the potential to add a great deal of value to the company for years to come.

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APPENDIX A

SELF-ASSESSMENT SURVEY

SDE Development Program

Self Assessment Survey

Name: _____

Discipline: _____

Office: _____

Years Experience: _____

Instructions:

This survey has been developed as a means of measuring the success of the SDE Training Program. It has been constructed in three parts; Front End Planning, Project Execution, and Project Completion. These sections are found on separate tabs at the bottom of the screen, each representing a Module of the training program. This self assessment should only take about 30 minutes, but it is very important that you complete it frankly and honestly and then return it as the instructions indicate.

1. Save this file with your name as the title.
2. Fill in the name, discipline, office, and years experience information at the top of this page.
3. Review the following three tabs and place an "x" directly under the desired number for each question.
4. For each major heading in **bold**, indicate the level of implementation that has been seen since the conclusion of the course.
5. Save the file again once all questions have been answered, and return the survey via email.

Responses will be kept confidential. Personal information will only be used to assure that all participants have completed a survey. No documentation that comes from this data will contain names. Finally, the survey has been developed using this electronic format in an effort to reduce the amount of paper used. Please return this as soon as possible. Thank you.

SDE Self Assessment Survey

Module 1 - Front End Planning

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

	Evaluation Criteria - General Knowledge	Level of Understanding: Pre-Training	Level of Understanding: Post-Training	Level of Implementation
Front End Planning	**Understanding Objectives**			1 2 3 4 5
	Understand that objectives are defined as the success criterion.	1 2 3 4 5	1 2 3 4 5	
	Understand that there may be multiple alternatives that may satisfy the objectives for the project.	1 2 3 4 5	1 2 3 4 5	
	Understand that project performance measures are not the same as project objectives.	1 2 3 4 5	1 2 3 4 5	
	Understand that the phases of objectives setting include formation, communication, and integration.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance for objectives to be specific, identifiable, attainable, controllable, assignable, and realistic.	1 2 3 4 5	1 2 3 4 5	
	Understand that the three dimensions of alignment include organizational hierarchy, multi-organizational boundaries, and the project life cycle.	1 2 3 4 5	1 2 3 4 5	

	Understand that objectives may change or be modified due to a dynamic market environment.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of regularly measuring alignment. These alignment measures should include team averages and respondent ranges.	1 2 3 4 5	1 2 3 4 5	
	Feasibility Phase			1 2 3 4 5
	Understand the importance of defining required deliverables and sponsor expectations.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of confirming the reliability of all early project assumptions.	1 2 3 4 5	1 2 3 4 5	
	Understand the process to develop early estimates and early schedule milestones.	1 2 3 4 5	1 2 3 4 5	
	Understand the SDEs role in developing early design basis information.	1 2 3 4 5	1 2 3 4 5	
	Understand the drivers for judging between alternative sites and technologies.	1 2 3 4 5	1 2 3 4 5	
	Concept Phase			1 2 3 4 5
	Understand the importance of validating all assumptions generated in the feasibility phase.	1 2 3 4 5	1 2 3 4 5	

	Understand the content and importance of the design basis document.	1 2 3 4 5	1 2 3 4 5	
	Understand how to structure a successful analysis of project alternatives.	1 2 3 4 5	1 2 3 4 5	
	Understand how to differentiate between conceptual and preliminary estimating techniques.	1 2 3 4 5	1 2 3 4 5	
	Understand how to evaluate progress during the execution of Front End Planning.	1 2 3 4 5	1 2 3 4 5	
	Detailed Scope Phase			1 2 3 4 5
	Understand how to identify and define deliverables for a detailed project scope.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of a risk management strategy as it relates to Front End Planning.	1 2 3 4 5	1 2 3 4 5	
	Understand the need to define the scope of facilities and the scope of services to be provided.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of startup planning in the Front End Planning process.	1 2 3 4 5	1 2 3 4 5	
	Understand issues related to professional licensure and compliance procedures.	1 2 3 4 5	1 2 3 4 5	

	Understand the importance and issues related to federal, state, and local permits.	1 2 3 4 5	1 2 3 4 5	
	Understand the interrelationship of the various design disciplines.	1 2 3 4 5	1 2 3 4 5	
	Understand the important issues regarding design for safety.	1 2 3 4 5	1 2 3 4 5	
	Understand the process to estimate design work hours.	1 2 3 4 5	1 2 3 4 5	
	Understand the SDEs role in providing input to estimates and schedules.	1 2 3 4 5	1 2 3 4 5	
	Understand the SDEs role in the Front End Planning process with respect to materials management.	1 2 3 4 5	1 2 3 4 5	
	Understand how to evaluate the Front End Planning process using the PDRI tool.	1 2 3 4 5	1 2 3 4 5	
	Contractual Relationships			1 2 3 4 5
	Understand the similarities and differences in basic contract types.	1 2 3 4 5	1 2 3 4 5	
	Understand incentivized and target price contract.	1 2 3 4 5	1 2 3 4 5	

	Understand basic project delivery strategies.	1 2 3 4 5	1 2 3 4 5	
	Understand key clauses that commonly exist in design construction contracts.	1 2 3 4 5	1 2 3 4 5	
	Understand the relationship between risk management and the structure of contracts.	1 2 3 4 5	1 2 3 4 5	
	Understand how change management is reflected in contract strategy.	1 2 3 4 5	1 2 3 4 5	

SDE Self Assessment Survey

Module 2 - Project Execution

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

Evaluation Criteria - General Knowledge	Level of Understanding: Pre-Training	Level of Understanding: Post-Training	Level of Implementation
Preparing for Project Execution			1 2 3 4 5
Understand the difference between Scope of Work and the Project Execution Plan; the Design Basis Document and the Engineering Execution plan as supporting documentation.	1 2 3 4 5	1 2 3 4 5	
Understand the content and importance of the Design Basis Document.	1 2 3 4 5	1 2 3 4 5	
Risk Management			1 2 3 4 5
Understand the three phase process of risk management; identification, measurement or evaluation, and management or mitigation.	1 2 3 4 5	1 2 3 4 5	
Understand that measurement of risk must address frequency and severity.	1 2 3 4 5	1 2 3 4 5	
Understand the importance of the risk category guidelines found in the PEP.	1 2 3 4 5	1 2 3 4 5	

	Understand uncertainty as it relates to risk.	1 2 3 4 5	1 2 3 4 5	
	Understand risk control techniques, such as risk sharing, risk transfer, and contingency planning.	1 2 3 4 5	1 2 3 4 5	
	Contract Management			1 2 3 4 5
	Understand contractual clauses that allocate risk.	1 2 3 4 5	1 2 3 4 5	
	Understand the SDE's role in subcontracting for services.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of keeping technical terms out of project specifications.	1 2 3 4 5	1 2 3 4 5	
	Understand the SDE's role in processing purchase orders.	1 2 3 4 5	1 2 3 4 5	
	Understand the process for managing Requests for Information (RFI's).	1 2 3 4 5	1 2 3 4 5	
	Change Management			1 2 3 4 5
	Understand types of change; scope, budget transfers, project development change.	1 2 3 4 5	1 2 3 4 5	

	Understand the direct and consequential impacts of change on project success.	1 2 3 4 5	1 2 3 4 5	
	Understand the process for effective change management; including change recognition, evaluation, implementation, and continuous improvement from lessons learned.	1 2 3 4 5	1 2 3 4 5	
	Understand the process for managing field requests for changes (RFIs an FCRs).	1 2 3 4 5	1 2 3 4 5	
	Understand how to recognize scope change versus changes to the Project Execution Plan.	1 2 3 4 5	1 2 3 4 5	
	Constructability			1 2 3 4 5
	Understand constructability versus value engineering.	1 2 3 4 5	1 2 3 4 5	
	Understand the cost and schedule benefits of a proactive constructability program.	1 2 3 4 5	1 2 3 4 5	
	Understand the constructability process and its benefit to the project.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of evaluating the applicability of prefab, preassembly, modularization, and off site fabrication (PPMOF).	1 2 3 4 5	1 2 3 4 5	

	Design Control			1 2 3 4 5
	Understand the importance of effective design control in the egineering work process.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of independent design reviews (IEDRs).	1 2 3 4 5	1 2 3 4 5	
	Understand the role of the licensed engineer within the project team.	1 2 3 4 5	1 2 3 4 5	
	Work Breakdown Structure			1 2 3 4 5
	Understand the importance of the process to generate a work breakdown structure.	1 2 3 4 5	1 2 3 4 5	
	Understand the relationship of Work Breakdown Structure to the Cost Breakdown Structure.	1 2 3 4 5	1 2 3 4 5	
	Understand the Work Breakdown Structure as a prerequisite to scheduling and estimating.	1 2 3 4 5	1 2 3 4 5	
	Cost Management			1 2 3 4 5
	Understand the difference between direct and indirect cost on a project.	1 2 3 4 5	1 2 3 4 5	

	Understand issues related to estimating accuracy and the estimate as a predictive range.	1 2 3 4 5	1 2 3 4 5	
	Understand estimating types and estimating techniques.	1 2 3 4 5	1 2 3 4 5	
	Understand how estimating work hours relates to project schedule.	1 2 3 4 5	1 2 3 4 5	
	Understand the SDE's role in estimating quantities and equipment cost.	1 2 3 4 5	1 2 3 4 5	
	Schedule Management			1 2 3 4 5
	Understand how the schedule reflects the Project Execution Plan.	1 2 3 4 5	1 2 3 4 5	
	Understand that activities in the schedule are generated from the Work Breakdown Structure.	1 2 3 4 5	1 2 3 4 5	
	Understand how predecessor and successor relationships are determined.	1 2 3 4 5	1 2 3 4 5	
	Understand the process for duration determination.	1 2 3 4 5	1 2 3 4 5	
	Understand the differences between total float and free float.	1 2 3 4 5	1 2 3 4 5	

	Understand resource leveling and resource constraints.	1 2 3 4 5	1 2 3 4 5	
	Understand the generation of a cumulative cost curve as the baseline condition for project execution.	1 2 3 4 5	1 2 3 4 5	
	Understand issues associated with determining percent complete.	1 2 3 4 5	1 2 3 4 5	
	Calculating Variances			1 2 3 4 5
	Understand the process to calculate performance indices (PIs) and schedule performance indices (SPIs).	1 2 3 4 5	1 2 3 4 5	
	Understand how PIs and SPI's are used to predict project performance.	1 2 3 4 5	1 2 3 4 5	
	Understand the difference between SPI (WS) and SPI (OA), and how SPI (WS) helps identify if the project is working to the execution plan.	1 2 3 4 5	1 2 3 4 5	
	Materials Management			1 2 3 4 5
	Understand the integrated functions of materials management and the role of the SDE in the materials management process.	1 2 3 4 5	1 2 3 4 5	
	Understand how the materials management process is adjusted for the different material categories, such as bulk materials, engineered equipment and prefab materials.	1 2 3 4 5	1 2 3 4 5	

	Understand the project benefits of an effective materials management program.	1 2 3 4 5	1 2 3 4 5	
	Information Management			1 2 3 4 5
	Understand the role of information management as it relates to project planning and project execution.	1 2 3 4 5	1 2 3 4 5	
	Understand the difference in managing data and managing documents.	1 2 3 4 5	1 2 3 4 5	
	Understand management techniques for managing information accessibility and info security.	1 2 3 4 5	1 2 3 4 5	
	Understand current tools for managing the flow of information.	1 2 3 4 5	1 2 3 4 5	

SDE Self Assessment Survey

Module 3 - Project Completion and Team Dynamics

1 = Little
2 = Some
3 = Average
4 = Much
5 = Proficient or Expert

Evaluation Criteria - General Knowledge	Level of Understanding: Pre-Training	Level of Understanding: Post-Training	Level of Implementation
Project Start-up			1 2 3 4 5
Understand the importance of project start-up to project success.	1 2 3 4 5	1 2 3 4 5	
Understand the importance of initiating start-up planning during the FEP process.	1 2 3 4 5	1 2 3 4 5	
Understand how start-up varies between industries and project types.	1 2 3 4 5	1 2 3 4 5	
Understand the process for effective start-up.	1 2 3 4 5	1 2 3 4 5	
Understand the relationship between start-up and contract incentives.	1 2 3 4 5	1 2 3 4 5	
Understand the role of the SDE in the start-up process.	1 2 3 4 5	1 2 3 4 5	

	Project Close-out			1 2 3 4 5
	Understand the multi-dimensions of project close-out (statutory, financial, contractual, operational, construction, customer expectations, and collection and documentation of Lessons Learned).	1 2 3 4 5	1 2 3 4 5	
	Understand the role of the SDE in the process for project close-out.	1 2 3 4 5	1 2 3 4 5	
	Team Building Concepts			1 2 3 4 5
	Understand the characteristics of an effective team.	1 2 3 4 5	1 2 3 4 5	
	Understand team member and team leader roles and responsibilities.	1 2 3 4 5	1 2 3 4 5	
	Understand the importance of differing personality types.	1 2 3 4 5	1 2 3 4 5	
	Understand the ways to manage team conflict.	1 2 3 4 5	1 2 3 4 5	
	Understand tools and techniques to maintain team alignment.	1 2 3 4 5	1 2 3 4 5	

	Leadership Applications			1 2 3 4 5
	Understand leadership traits and how they apply to design teams.	1 2 3 4 5	1 2 3 4 5	
	Understand barriers to effective leadership and how to overcome them.	1 2 3 4 5	1 2 3 4 5	
	Understand the expectations of leaders and how to improve personal performance.	1 2 3 4 5	1 2 3 4 5	
	Mentoring Responsibilities			1 2 3 4 5
	Understand the SDE's role in employee development through mentoring.	1 2 3 4 5	1 2 3 4 5	
	Understand the roles, responsibilities, and benefits of the mentor and the mentee.	1 2 3 4 5	1 2 3 4 5	

APPENDIX B

SURVEY RESPONSE DATA

	Pre-Training Responses																																							
Questions	SDE 1	SDE 2	SDE 3	SDE 4	SDE 5	SDE 6	SDE 7	SDE 8	SDE 9	SDE 10	SDE 11	SDE 12	SDE 13	SDE 14	SDE 15	SDE 16	SDE 17	SDE 18	SDE 19	SDE 20	SDE 21	SDE 22	SDE 23	SDE 24	SDE 25	SDE 26	SDE 27	SDE 28	SDE 29	SDE 30	SDE 31	SDE 32	SDE 33	SDE 34	SDE 36	SDE 37	SDE 38	Average
A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	2	3	3	2	3	1	3	2	2	5	3	1	3	3	3	2	3	2	1	2	2	1	3	2	3	3	1	2	1	2	2	2	2	2	2	3	1	2.243
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3	3	2	5	3	3	1	2	2	1	3	1	1	3	3	3	1	3	2	1	3	3	2	2	2	1	2	1	2	2	1	2	2	1	3	2	4	2	2.162
4	2	1	4	2	2	1	2	1	1	2	2	1	2	2	3	1	4	1	1	3	2	1	1	3	1	2	1	3	1	1	1	1	3	5	2	2	1	1.865
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F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	Post-Training Responses																																															
Questions	SDE 1	SDE 2	SDE 3	SDE 4	SDE 5	SDE 6	SDE 7	SDE 8	SDE 9	SDE 10	SDE 11	SDE 12	SDE 13	SDE 14	SDE 15	SDE 16	SDE 17	SDE 18	SDE 19	SDE 20	SDE 21	SDE 22	SDE 23	SDE 24	SDE 25	SDE 26	SDE 27	SDE 28	SDE 29	SDE 30	SDE 31	SDE 32	SDE 33	SDE 34	SDE 36	SDE 37	SDE 38	Average
A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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4	4	3	4	3	5	3	4	4	4	1	3	4	4	4	4	3	4	3	4	4	4	3	3	3	4	4	5	5	3	5	3	3	3	3	4	4	3	3.622
5	4	4	5	4	5	3	4	4	4	2	4	3	4	5	4	4	4	3	3	1	4	4	5	3	4	4	5	5	3	5	4	3	3	4	4	4	3	3.811
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V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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APPENDIX C

DATA DISTRIBUTION IN PERCENTAGES

Module 1 - Front End Planning

		Percentage - Pre-Training					Percentage - Post-Training				
	Evaluation Criteria - General Knowledge	Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5	Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5
A	**Understanding Objectives**	-	-	-	-	-	-	-	-	-	-
1	Understand that objectives are defined as the success criterion.	19%	43%	35%	0%	3%	0%	0%	5%	41%	54%
2	Understand that there may be multiple alternatives that may satisfy the objectives for the project.	3%	19%	46%	22%	11%	0%	0%	16%	43%	41%
3	Understand that project performance measures are not the same as project objectives.	27%	38%	30%	3%	3%	0%	0%	14%	54%	32%
4	Understand that the phases of objectives setting include formation, communication, and integration.	46%	32%	14%	5%	3%	0%	3%	30%	49%	19%
5	Understand the importance for objectives to be specific, identifiable, attainable, controllable, assignable, and realistic.	14%	49%	24%	11%	3%	0%	3%	14%	43%	41%
6	Understand that the three dimensions of alignment include organizational hierarchy, multi-organizational boundaries, and the project life cycle.	57%	38%	5%	0%	0%	0%	0%	19%	59%	22%
7	Understand that objectives may change or be modified due to a dynamic market environment.	8%	16%	51%	19%	5%	0%	0%	11%	54%	35%
8	Understand the importance of regularly measuring alignment. These alignment measures should include team averages and respondent ranges.	57%	30%	14%	0%	0%	0%	3%	16%	54%	27%
B	**Feasibility Phase**	-	-	-	-	-	-	-	-	-	-
1	Understand the importance of defining required deliverables and sponsor expectations.	11%	30%	32%	24%	3%	0%	0%	11%	54%	35%
2	Understand the importance of confirming the reliability of all early project assumptions.	11%	24%	41%	24%	0%	0%	0%	11%	46%	43%
3	Understand the process to develop early estimates and early schedule milestones.	24%	35%	27%	8%	5%	0%	0%	27%	46%	27%
4	Understand the SDEs role in developing early design basis information.	24%	41%	14%	19%	3%	0%	0%	14%	51%	35%
5	Understand the drivers for judging between alternative sites and techno	22%	43%	27%	8%	0%	0%	0%	27%	57%	16%
C	**Concept Phase**	-	-	-	-	-	-	-	-	-	-
1	Understand the importance of validating all assumptions generated in the feasibility phase.	11%	30%	35%	24%	0%	0%	0%	19%	49%	32%
2	Understand the content and importance of the design basis document.	19%	27%	22%	24%	8%	0%	0%	5%	54%	41%
3	Understand how to structure a successful analysis of project alternatives.	41%	30%	24%	5%	0%	0%	5%	41%	46%	8%
4	Understand how to differentiate between conceptual and preliminary estimating techniques.	46%	38%	14%	3%	0%	3%	14%	38%	35%	11%
5	Understand how to evaluate progress during the execution of Front End Planning.	51%	35%	11%	3%	0%	0%	8%	41%	43%	8%

D	**Detailed Scope Phase**	-	-	-	-	-	-	-	-	-	-	-
1	Understand how to identify and define deliverables for a detailed project scope.	11%	35%	35%	16%	3%	0%	0%	11%	59%	30%	
2	Understand the importance of a risk management strategy as it relates to Front End Planning.	35%	46%	16%	3%	0%	0%	3%	35%	49%	14%	
3	Understand the need to define the scope of facilities and the scope of services to be provided.	19%	24%	38%	16%	3%	0%	3%	19%	43%	35%	
4	Understand the importance of startup planning in the Front End Planning process.	41%	30%	22%	5%	3%	0%	11%	11%	49%	30%	
5	Understand issues related to professional licensure and compliance procedures.	24%	27%	41%	5%	3%	0%	3%	30%	46%	22%	
6	Understand the importance and issues related to federal, state, and local permits.	19%	24%	32%	24%	0%	0%	5%	22%	65%	8%	
7	Understand the interrelationship of the various design disciplines.	5%	14%	41%	35%	5%	0%	0%	14%	51%	35%	
8	Understand the important issues regarding design for safety.	3%	27%	38%	16%	16%	0%	0%	14%	49%	38%	
9	Understand the process to estimate design work hours.	5%	30%	35%	30%	0%	0%	0%	19%	65%	16%	
10	Understand the SDEs role in providing input to estimates and schedules.	11%	35%	27%	22%	5%	0%	0%	5%	68%	27%	
11	Understand the SDEs role in the Front End Planning process with respect to materials management.	35%	30%	27%	5%	3%	0%	0%	32%	51%	16%	
12	Understand how to evaluate the Front End Planning process using the PDRI tool.	86%	5%	3%	5%	0%	0%	8%	30%	49%	14%	
E	**Contractual Relationships**	-	-	-	-	-	-	-	-	-	-	-
1	Understand the similarities and differences in basic contract types.	35%	49%	14%	3%	0%	0%	3%	46%	46%	5%	
2	Understand incentivized and target price contract.	35%	51%	14%	0%	0%	0%	5%	27%	57%	11%	
3	Understand basic project delivery strategies.	32%	35%	24%	8%	0%	0%	8%	32%	59%	0%	
4	Understand key clauses that commonly exist in design construction contracts.	49%	38%	8%	5%	0%	3%	5%	30%	54%	8%	
5	Understand the relationship between risk management and the structure of contracts.	41%	41%	14%	5%	0%	0%	3%	38%	49%	11%	
6	Understand how change management is reflected in contract strategy.	32%	41%	24%	3%	0%	0%	5%	30%	57%	8%	

Module 2 - Project Execution

	Evaluation Criteria - General Knowledge	Percentage - Pre-Training					Percentage - Post-Training				
		Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5	Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5
F	**Preparing for Project Execution**	-	-	-	-	-	-	-	-	-	-
1	Understand the difference between Scope of Work and the Project Execution Plan; the Design Basis Document and the Engineering Execution plan as supporting documentation.	24%	38%	32%	5%	0%	0%	3%	11%	57%	30%
2	Understand the content and importance of the Design Basis Document.	11%	35%	32%	19%	3%	0%	0%	19%	41%	41%
G	**Risk Management**	-	-	-	-	-	-	-	-	-	-
1	Understand the three phase process of risk management; identification, measurement or evaluation, and management or mitigation.	38%	43%	14%	3%	3%	0%	3%	22%	62%	14%
2	Understand that measurement of risk must address frequency and severity.	38%	41%	14%	0%	8%	0%	3%	8%	59%	30%
3	Understand the importance of the risk category guidelines found in the PEP.	57%	38%	5%	0%	0%	3%	5%	35%	49%	8%
4	Understand uncertainty as it relates to risk.	35%	32%	22%	5%	5%	0%	3%	24%	51%	22%
5	Understand risk control techniques, such as risk sharing, risk transfer, and contingency planning.	49%	38%	11%	3%	0%	0%	3%	38%	49%	11%
H	**Contract Management**	-	-	-	-	-	-	-	-	-	-
1	Understand contractual clauses that allocate risk.	57%	35%	8%	0%	0%	0%	11%	41%	49%	0%
2	Understand the SDE's role in subcontracting for services.	35%	49%	11%	3%	3%	0%	8%	35%	54%	3%
3	Understand the importance of keeping technical terms out of project specifications.	46%	30%	16%	3%	5%	0%	0%	22%	51%	27%
4	Understand the SDE's role in processing purchase orders.	30%	38%	14%	14%	5%	0%	3%	30%	51%	16%
5	Understand the process for managing Requests for Information (RFI's).	24%	27%	30%	14%	5%	0%	3%	22%	51%	24%
I	**Change Management**	-	-	-	-	-	-	-	-	-	-
1	Understand types of change; scope, budget transfers, project development change.	16%	51%	22%	8%	3%	0%	3%	22%	57%	19%
2	Understand the direct and consequential impacts of change on project success.	11%	35%	35%	16%	3%	0%	0%	14%	54%	32%
3	Understand the process for effective change management; including change recognition, evaluation, implementation, and continuous improvement from lessons learned.	27%	41%	24%	3%	5%	0%	3%	22%	51%	24%
4	Understand the process for managing field requests for changes (RFIs an FCRs).	24%	38%	16%	14%	8%	0%	5%	24%	51%	19%
5	Understand how to recognize scope change versus changes to the Project Execution Plan.	27%	43%	24%	5%	0%	0%	0%	35%	49%	16%

J	**Constructability**	-	-	-	-	-	-	-	-	-	-	-
1	Understand constructability versus value engineering.	24%	41%	22%	8%	5%	0%	5%	22%	43%	30%
2	Understand the cost and schedule benefits of a proactive constructability program.	32%	32%	22%	8%	5%	0%	0%	27%	43%	30%
3	Understand the constructability process and its benefit to the project.	30%	35%	19%	11%	5%	0%	0%	22%	57%	22%
4	Understand the importance of evaluating the applicability of prefab, preassembly, modularization, and off site fabrication (PPMOF).	30%	27%	16%	19%	8%	0%	3%	19%	51%	27%
K	**Design Control**	-	-	-	-	-	-	-	-	-	-	-
1	Understand the importance of effective design control in the egineering work process.	11%	27%	46%	5%	11%	0%	0%	8%	57%	35%
2	Understand the importance of independent design reviews (IEDRs).	22%	16%	35%	16%	11%	0%	3%	16%	46%	35%
3	Understand the role of the licensed engineer within the project team.	11%	24%	32%	22%	11%	3%	0%	3%	54%	41%
L	**Work Breakdown Structure**	-	-	-	-	-	-	-	-	-	-	-
1	Understand the importance of the process to generate a work breakdown structure.	24%	41%	24%	8%	3%	0%	3%	11%	59%	27%
2	Understand the relationship of Work Breakdown Structure to the Cost Breakdown Structure.	43%	32%	22%	0%	3%	0%	3%	35%	59%	3%
3	Understand the Work Breakdown Structure as a prerequisite to scheduling and estimating.	38%	24%	35%	3%	0%	3%	0%	16%	68%	14%
M	**Cost Management**	-	-	-	-	-	-	-	-	-	-	-
1	Understand the difference between direct and indirect cost on a project.	30%	32%	24%	14%	0%	0%	5%	19%	54%	22%
2	Understand issues related to estimating accuracy and the estimate as a predictive range.	22%	49%	24%	3%	3%	0%	5%	32%	51%	11%
3	Understand estimating types and estimating techniques.	27%	46%	24%	3%	0%	0%	5%	35%	43%	16%
4	Understand how estimating work hours relates to project schedule.	11%	16%	54%	11%	8%	0%	0%	24%	54%	22%
5	Understand the SDE's role in estimating quantities and equipment cost.	11%	16%	51%	16%	5%	0%	3%	11%	49%	38%
N	**Schedule Management**	-	-	-	-	-	-	-	-	-	-	-
1	Understand how the schedule reflects the Project Execution Plan.	24%	32%	22%	14%	8%	0%	0%	22%	57%	22%
2	Understand that activities in the schedule are generated from the Work Breakdown Structure.	30%	30%	30%	8%	3%	0%	0%	8%	65%	27%
3	Understand how predecessor and successor relationships are determined.	24%	32%	24%	14%	5%	0%	3%	14%	65%	19%
4	Understand the process for duration determination.	30%	32%	24%	5%	8%	0%	3%	14%	59%	24%

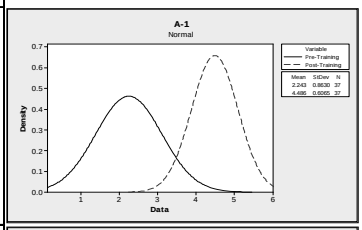
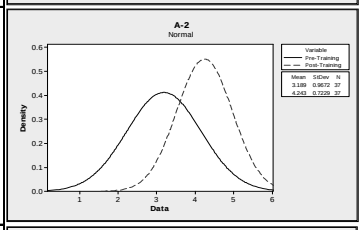
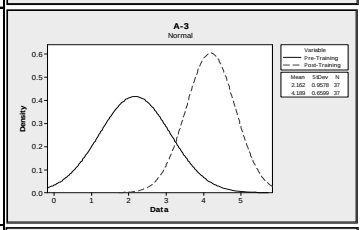
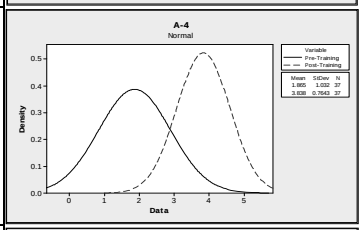
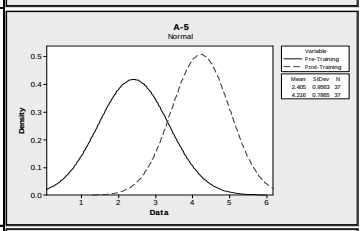
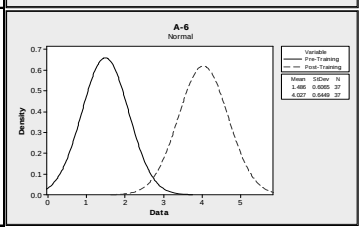
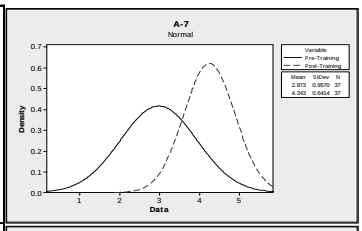
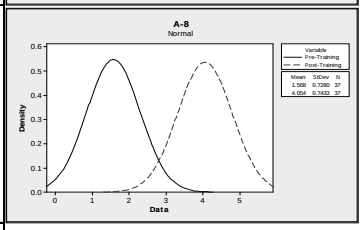
5	Understand the differences between total float and free float.	46%	35%	8%	3%	8%	0%	3%	14%	59%	24%
6	Understand resource leveling and resource constraints.	32%	38%	22%	3%	5%	0%	3%	30%	46%	22%
7	Understand the generation of a cumulative cost curve as the baseline condition for project execution.	54%	38%	3%	5%	0%	3%	11%	41%	43%	3%
8	Understand issues associated with determining percent complete.	24%	49%	19%	8%	0%	0%	0%	38%	49%	14%
O	**Calculating Variances**	-	-	-	-	-	-	-	-	-	-
1	Understand the process to calculate performance indices (PIs) and schedule performance indices (SPIs).	41%	32%	22%	3%	3%	0%	0%	38%	43%	19%
2	Understand how PIs and SPI's are used to predict project performance.	27%	43%	14%	11%	5%	0%	0%	30%	49%	22%
3	Understand the difference between SPI (WS) and SPI (OA), and how SPI (WS) helps identify if the project is working to the execution plan.	49%	27%	16%	5%	3%	3%	3%	30%	49%	16%
P	**Materials Management**	-	-	-	-	-	-	-	-	-	-
1	Understand the integrated functions of materials management and the role of the SDE in the materials management process.	35%	32%	30%	3%	0%	0%	5%	22%	62%	11%
2	Understand how the materials management process is adjusted for the different material categories, such as bulk materials, engineered equipment and prefab materials.	35%	41%	16%	8%	0%	0%	3%	27%	62%	8%
3	Understand the project benefits of an effective materials management program.	27%	46%	14%	5%	8%	0%	0%	16%	62%	22%
Q	**Information Management**	-	-	-	-	-	-	-	-	-	-
1	Understand the role of information management as it relates to project planning and project execution.	22%	38%	32%	8%	0%	3%	5%	16%	59%	16%
2	Understand the difference in managing data and managing documents.	24%	35%	32%	8%	0%	3%	5%	27%	54%	11%
3	Understand management techniques for managing information accessibility and info security.	19%	51%	27%	3%	0%	3%	5%	38%	43%	11%
4	Understand current tools for managing the flow of information.	22%	46%	30%	3%	0%	0%	11%	41%	38%	11%

Module 3 - Project Completion and Team Dynamics

		Percentage - Pre-Training					Percentage - Post-Training				
	Evaluation Criteria - General Knowledge	Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5	Little 1	Some 2	Average 3	Much 4	Proficient or Expert 5
R	**Project Start-up**	-	-	-	-	-	-	-	-	-	-
1	Understand the importance of project start-up to project success.	8%	32%	41%	14%	5%	0%	0%	11%	43%	46%
2	Understand the importance of initiating start-up planning during the FEP process.	38%	32%	22%	5%	3%	0%	3%	14%	46%	38%
3	Understand how start-up varies between industries and project types.	27%	43%	27%	0%	3%	3%	0%	49%	27%	22%
4	Understand the process for effective start-up.	43%	32%	14%	8%	3%	3%	0%	41%	46%	11%
5	Understand the relationship between start-up and contract incentives.	30%	41%	24%	5%	0%	3%	3%	24%	51%	19%
6	Understand the role of the SDE in the start-up process.	32%	38%	19%	11%	0%	3%	5%	35%	35%	22%
S	**Project Close-out**	-	-	-	-	-	-	-	-	-	-
1	Understand the multi-dimensions of project close-out (financial, contractual, operational, construction, customer expectations, and documentation of Lessons Learned).	43%	38%	16%	0%	3%	0%	3%	49%	43%	5%
2	Understand the role of the SDE in the process for project close-out.	35%	41%	16%	3%	5%	0%	0%	43%	43%	14%
T	**Team Building Concepts**	-	-	-	-	-	-	-	-	-	-
1	Understand the characteristics of an effective team.	8%	30%	43%	16%	3%	0%	3%	11%	57%	30%
2	Understand team member and team leader roles and responsibilities.	5%	22%	57%	14%	3%	0%	0%	11%	59%	30%
3	Understand the importance of differing personality types.	11%	30%	32%	14%	14%	0%	3%	16%	43%	38%
4	Understand the ways to manage team conflict.	16%	41%	30%	11%	3%	0%	3%	27%	46%	24%
5	Understand tools and techniques to maintain team alignment.	49%	30%	14%	8%	0%	0%	3%	30%	43%	24%
U	**Leadership Applications**	-	-	-	-	-	-	-	-	-	-
1	Understand leadership traits and how they apply to design teams.	11%	27%	43%	14%	5%	0%	3%	22%	51%	24%
2	Understand barriers to effective leadership and how to overcome them.	14%	46%	22%	16%	3%	0%	3%	30%	51%	16%
3	Understand the expectations of leaders and how to improve personal performance.	5%	38%	41%	14%	3%	0%	5%	14%	54%	27%
V	**Mentoring Responsibilities**	-	-	-	-	-	-	-	-	-	-
1	Understand the SDE's role in employee development through mentoring.	5%	35%	30%	14%	16%	0%	0%	5%	49%	46%
2	Understand the roles, responsibilities, and benefits of the mentor and the mentee.	5%	22%	32%	24%	16%	0%	0%	8%	54%	38%

APPENDIX D

DISTRIBUTION OF EVALUATION CRITERIA RESPONSES

A	
1	
2	
3	
4	
5	
6	
7	
8	
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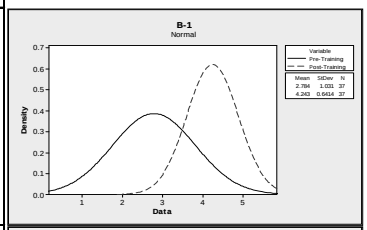
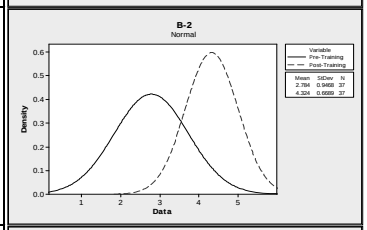
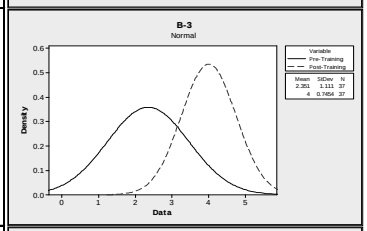
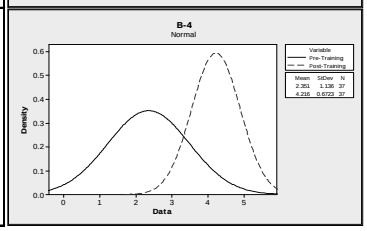
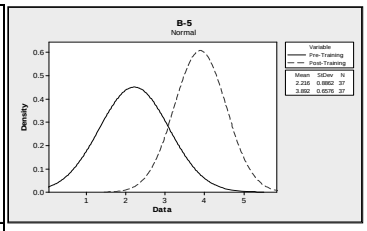
1	
2	
3	
4	

5	
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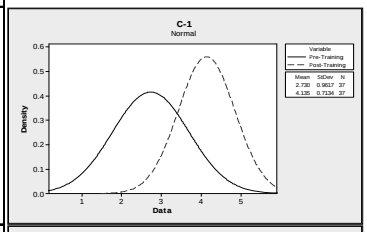
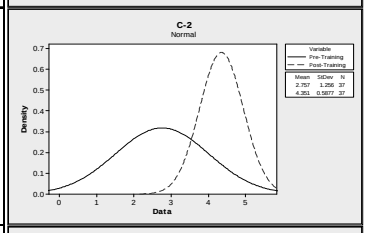
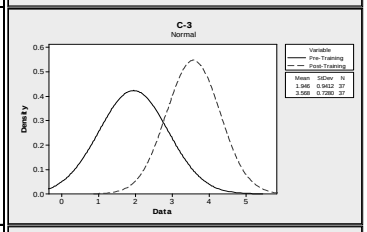
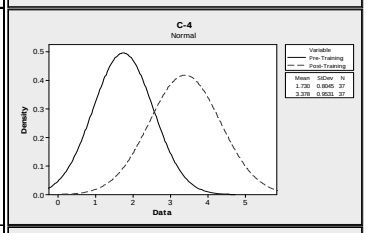
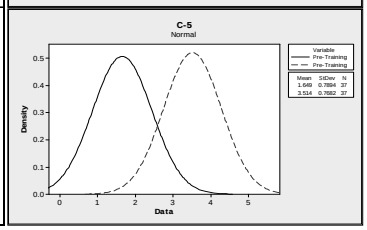
1	
2	
3	
4	
5	

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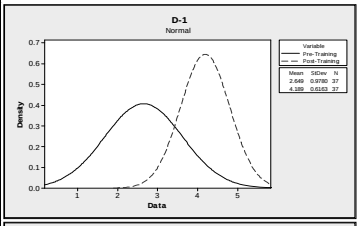
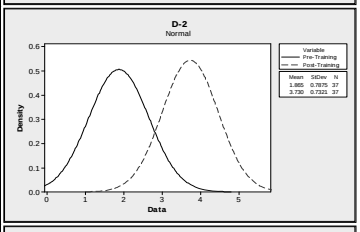
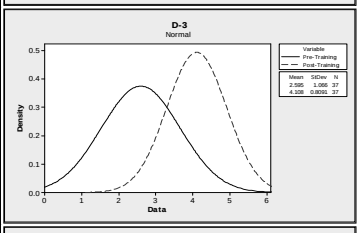
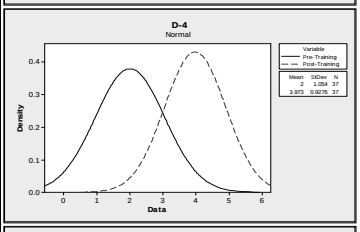
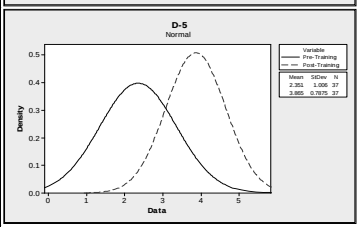
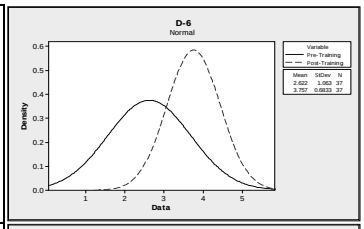
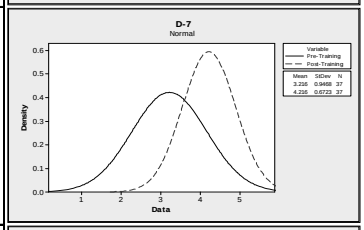
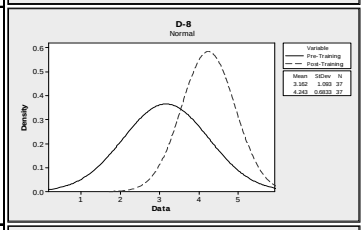
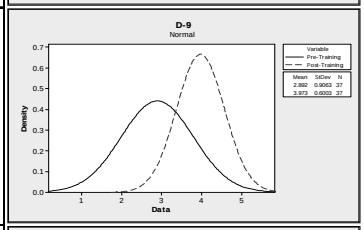
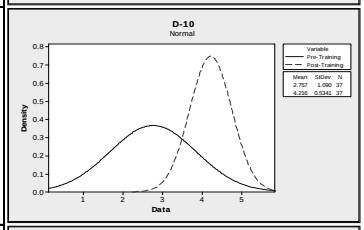
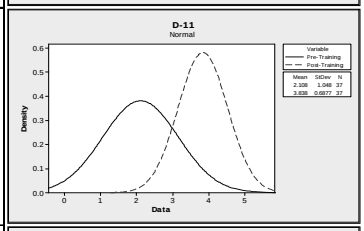
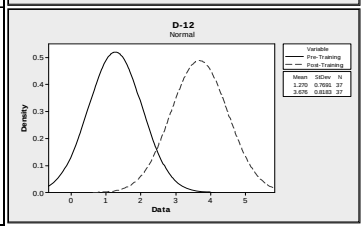
1	
2	
3	
4	
5	

6	
7	
8	
9	
10	
11	
12	

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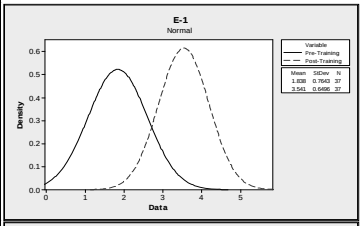
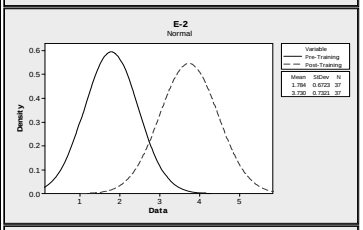
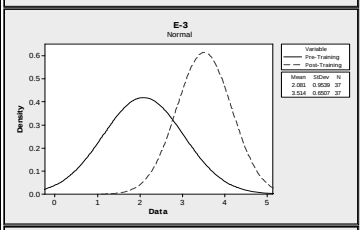
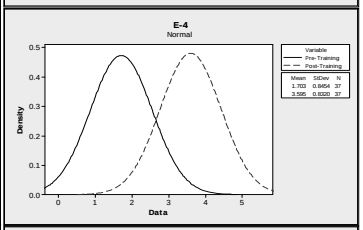
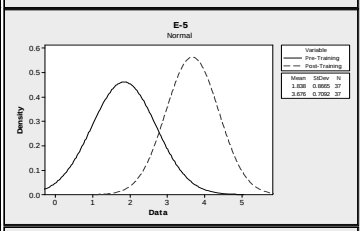
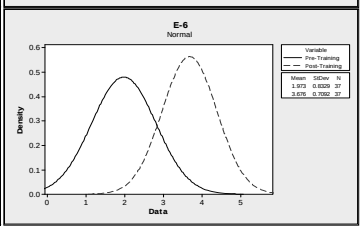
1	
2	
3	
4	
5	
6	

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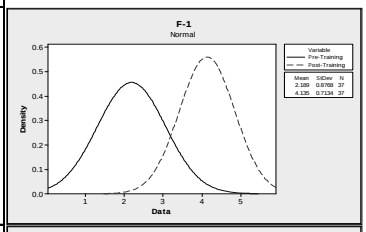
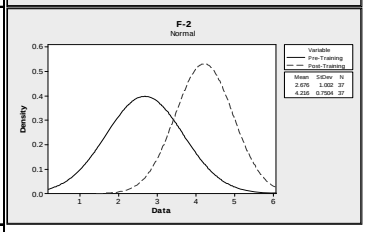
1	
2	
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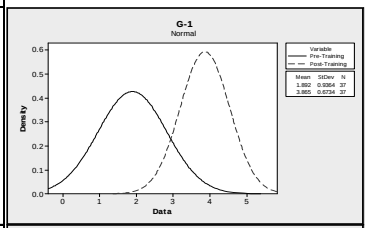
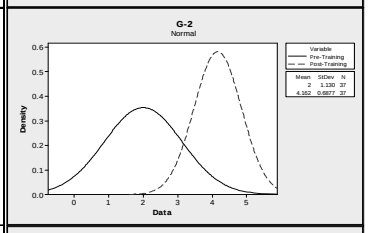
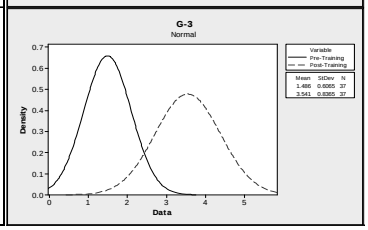
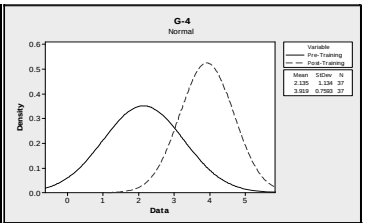
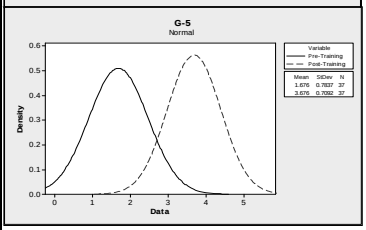
1	
2	
3	

4	
5	
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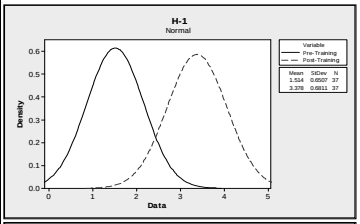
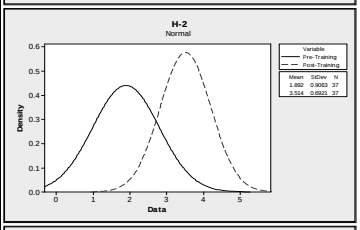
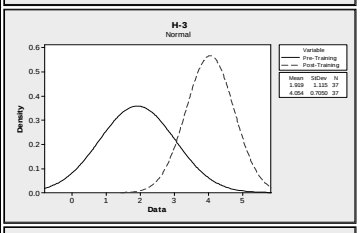
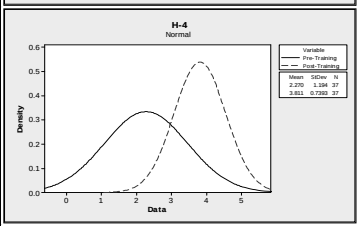
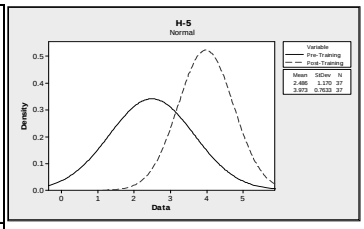
1	
2	
3	
4	

5	
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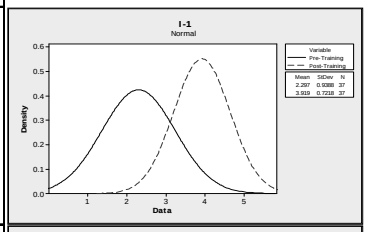
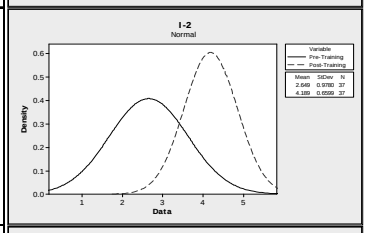
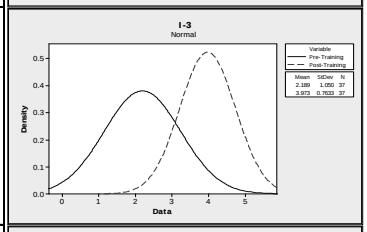
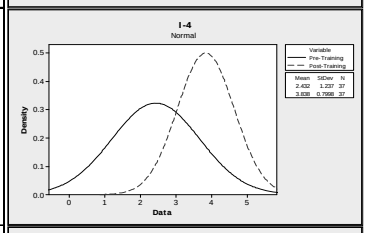
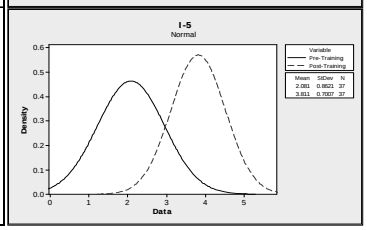
1	
2	
3	
4	
5	

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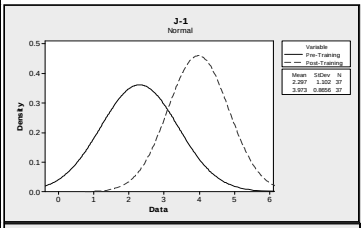
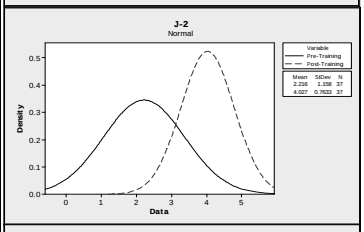
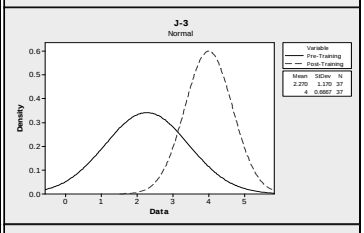
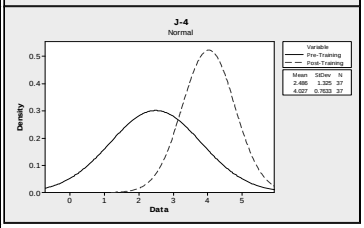
1	
2	
3	
4	
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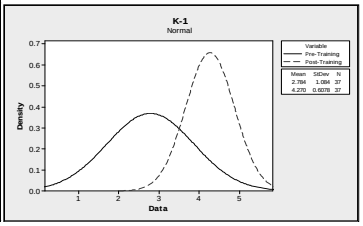
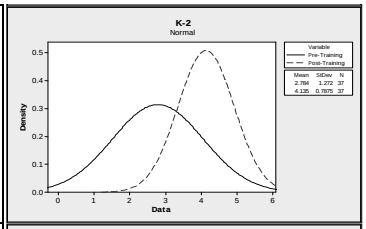
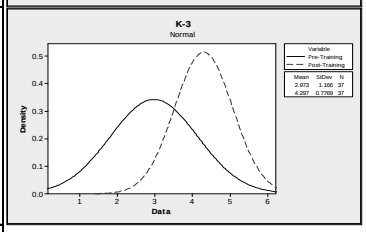
1	

2	
3	
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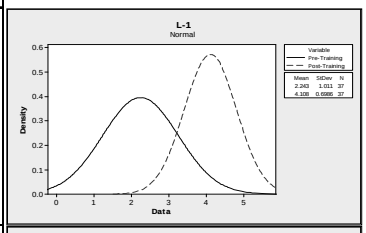
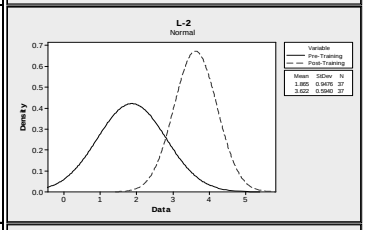
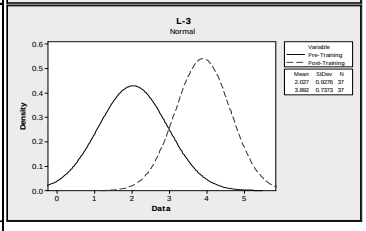
1	
2	
3	
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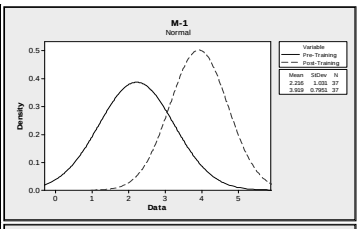
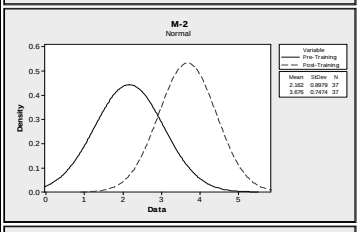
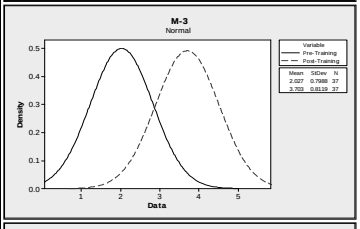
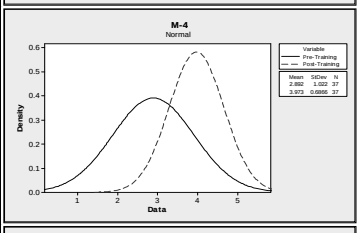
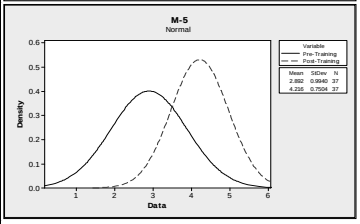
1	
2	
3	
4	
5	
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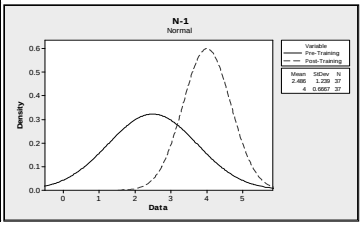
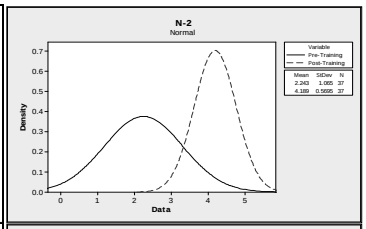
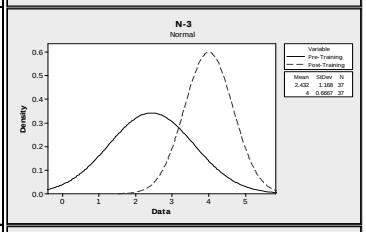
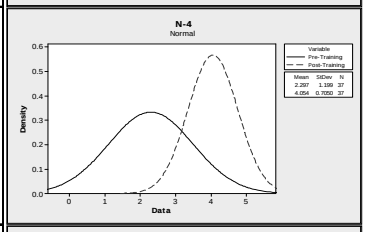
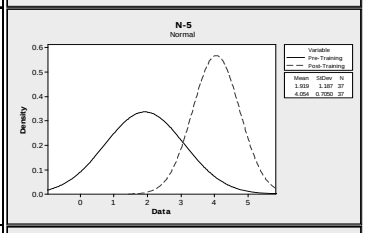
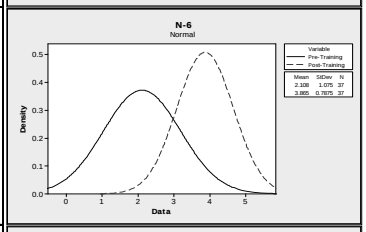
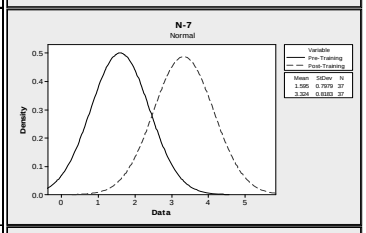
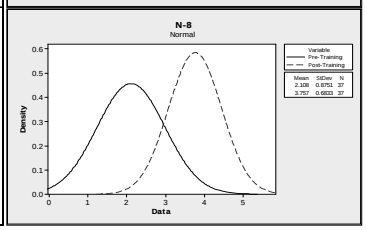
1	

2	
3	
4	
5	
6	
7	
8	

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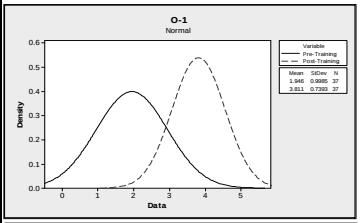
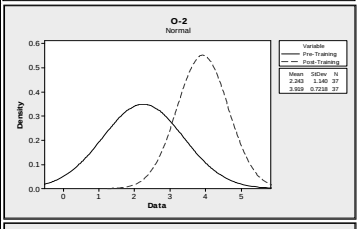
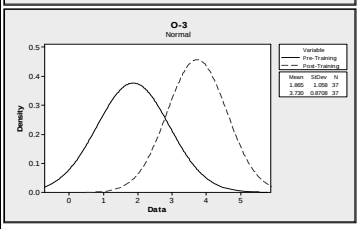
1	
2	
3	
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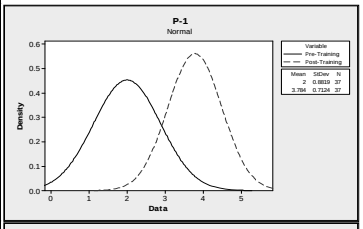
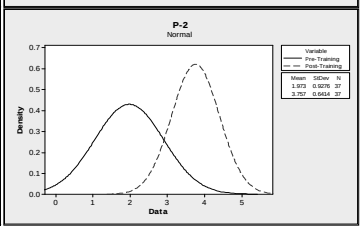
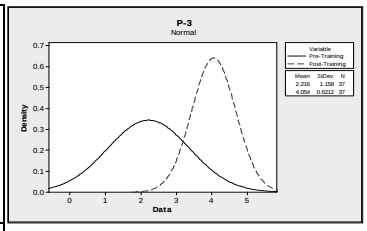
1	
2	

3	
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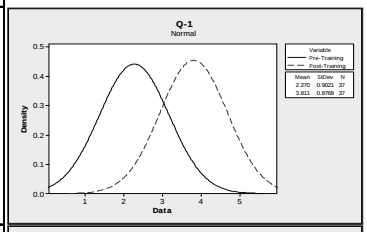
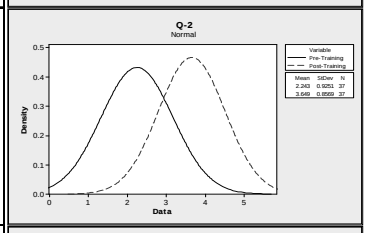
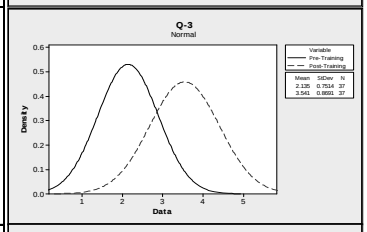
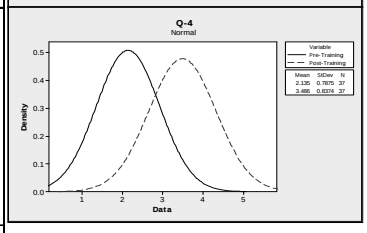
1	
2	
3	
4	
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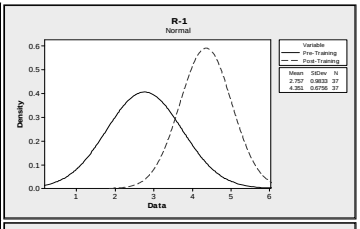
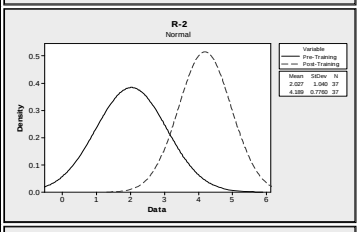
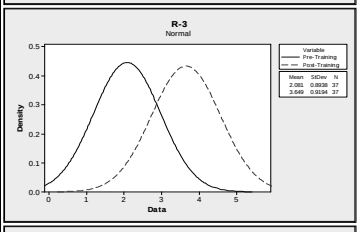
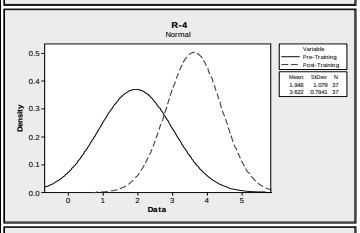
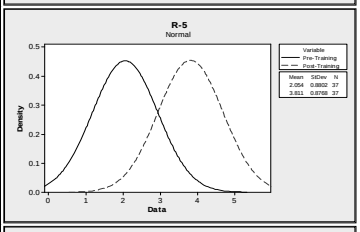
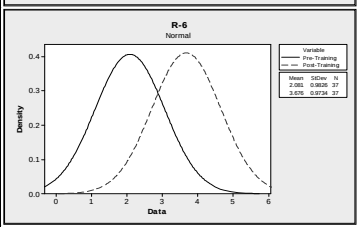
1	
2	
3	
4	
5	
6	

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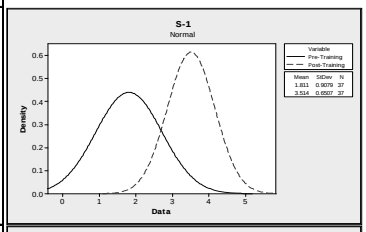
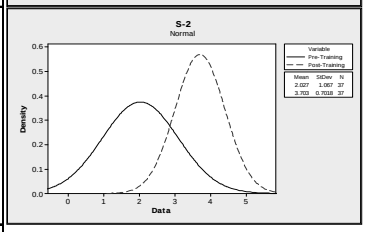
1	
2	
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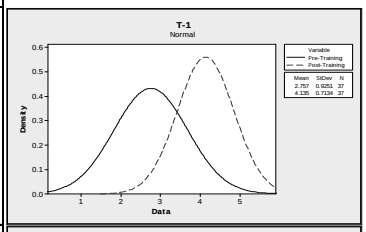
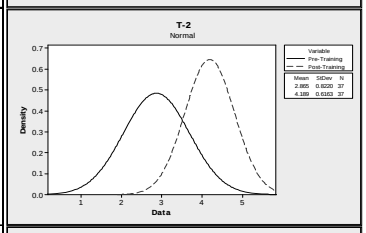
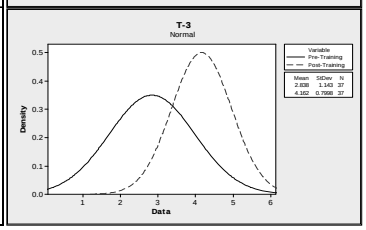
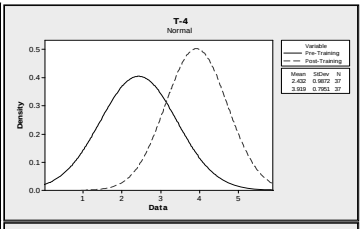
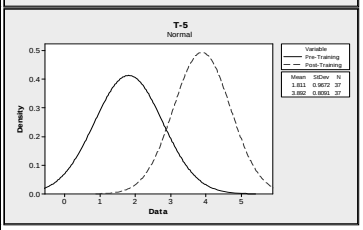
1	
2	
3	
4	
5	
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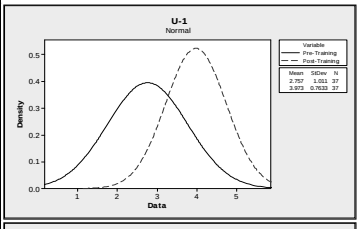
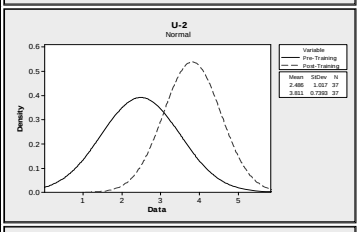
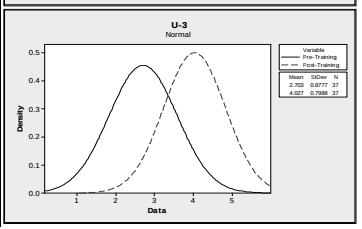
1	
2	
3	

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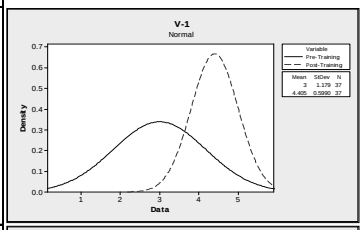
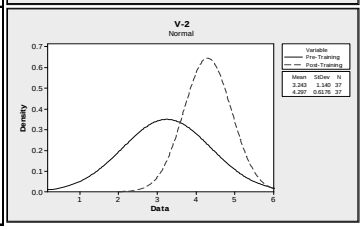
1	 V-1 Normal Density Data Variable Pre-Training Post-Training Mean StDev N 3 1.179 37 4.405 0.5990 37
2	 V-2 Normal Density Data Variable Pre-Training Post-Training Mean StDev N 3.343 1.140 37 4.297 0.6176 37