DESIGN AND DEVELOPMENT OF A STANDARDIZED MITSUBISHI PLC
PROGRAM TROUBLESHOOTING AND REPAIR TRAINING MANUAL FOR
MACHINE MAINTENANCE PERSONNEL AT TTAI

by

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ABSTRACT

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This research was conducted to design and develop a standardized Mitsubishi

PLC program troubleshooting and repair training manual for TTAI Machine Maintenance

(M/M) personnel. The researcher used a focus group to determine the design of the

training format and the content of the training manual.

The focus group meeting determined four main topics with twelve subtopics, four

performance objectives and a three day training schedule of four hours per day. Twelve

members from machine maintenance department who were hired in the past twelve

months were identified with skill deficiencies in utilizing the Mitsubishi PLC program.

Further, this research also makes recommendations on how to conduct and implement the summative evaluation based on the Kirkpatrick's four-level evaluation model.

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Chapter 1

INTRODUCTION

<u>Background</u>

Toyotetsu America, Inc. (TTAI), established and founded from Toyota Iron Works Co., Ltd. in 1995, is a subsidiary company of Toyota to supply stamped and welded automotive metal components to meet automotive market needs in North America. Their mission statement is: "becoming the number one automotive supplier with the best quality, just in time delivery and the lowest possible price based on TPS (Toyota Production System; continuous improvement)". TTAI is located at Somerset, KY, and currently has about 900 employees in total, including twenty Japanese top managers. The mid-level managers, supervisors and line workers are Americans.

There are 33 machine maintenance (M/M) members in M/M department with six of those being team leaders. Their major duties are to troubleshoot, repair, and maintain welding and stamping machines, robots, and other related equipment. For M/M members, it is vital to know how to operate a software program called the Mitsubishi PLC program that is used to create, test, troubleshoot, and modify electrical ladder diagrams in order to solve electric problems. The Mitsubishi PLC program is fundamental to troubleshooting both welding and stamping machine breakdowns.

Every three months, twenty Japanese employees from a parent company in Japan arrive at TTAI in Kentucky to provide technical support to American engineers, M/M members, and various other departments. These Japanese employees who visit TTAI for only three months are called Japanese supporters. The Japanese supporter's major duties vary depending upon which department they visit, but for the M/M department, it is to

provide training to M/M members in solving machine breakdown problems, and troubleshooting and repairing newly installed machines.

Currently, three M/M supporters are at TTAI to assist with daily production and to provide on-the- job training to M/M department members. Production is highly dependent upon the machine's condition; therefore, M/M members need to provide the best solutions whenever a machine breakdown occurs. They are responsible to keep machines in good condition so that breakdowns can be reduced, and down time is kept as short as possible.

Although the primary purpose of the Japanese supporters is to provide machine maintenance training to the workers, they spend most of their time repairing machines in order to keep up daily production volume. Maintenance training is required especially for those with less experience in using the Mitsubishi PLC program to solve electric related problems.

The M/M department supporters encourage American M/M members to use the Mitsubishi PLC program for electric troubleshooting because it is considered to be the most appropriate equipment in troubleshooting and repairing machine breakdowns in Japan. However, using the Mitsubishi PLC program and a laptop computer to troubleshoot electric circuits is a new approach for most of the M/M members. Learning how to utilize a laptop computer in troubleshooting is very fundamental in developing their maintenance skills.

The Japanese supporters provide training to M/M members who lack Knowledge, Skill, or Ability (KSA's) in using the Mitsubishi PLC program as a tool to solve electrical technical problems. Unfortunately, the present troubleshooting training is not

standardized and the quality and quantity of the training varies in each training session. In addition to the inconsistency in terms of quality and quantity, the training requires extra time for interpretation and TTAI is losing precious training time because of the language differences.

This study focuses on the design and development of a training manual for M/M members in learning how to utilize the Mitsubishi PLC program in troubleshooting. The training manual will be created based on a thorough research of required KSA's and discussions with supporters, team leaders, and group leaders in the M/M department.

Statement of the Problem

TTAI's present machine maintenance training on the Mitsubishi PLC program is ineffective. The training does not satisfy either the M/M members' or managements' demand. Therefore, TTAI should create a standardized training manual for M/M members in using the Mitsubishi PLC program for electrical troubleshooting.

Purpose of the Study

There is a deficiency in M/M members' KSA's in using the Mitsubishi PLC program for electrical troubleshooting. The purpose of this study is to create a standardized electrical troubleshooting and repair training manual for M/M members in using the Mitsubishi PLC program.

Research Objective

The primary research objective in this study was to design and develop a standardized Mitsubishi PLC program troubleshooting and repair training manual for TTAI machine maintenance personnel.

<u>Significance of the Study</u>

TTAI is presently experiencing rapid growth and change within the organization. TTAI has added new facilities and installed many new machines including ten press machines, approximately one-hundred welding lines, robots, and associated equipment, and also hired about 100 employees in various departments. Production depends highly on machine's condition. If M/M personnel fail to provide quick and appropriate solutions to the breakdowns, it will negatively influence the quality of the product and the productivity. TTAI must train M/M members in using a software package called the Mitsubishi PLC program because it is one way to prevent further loss in production time. To assure training effectiveness, a standardized training delivery approach needs to be developed and implemented.

<u>Limitations</u>

There are four limitations of this study:

1. Limited time to design and develop a training manual because M/M supporters stay in the US only for a three-month period.

2. Finding the appropriate technical language that is easy to understand by all the members in M/M department is time consuming.

3. Trainee's motivation to learn about using the Mitsubishi PLC program with a laptop computer may be not as high as supporters expect; therefore, trainees may not participate fully during the training.

4. Since the number of laptop computers with the Mitsubishi PLC program installed is limited, it may be difficult to obtain a laptop computer to conduct training.

<u>Definition of Terms</u>

Circuit — the complete path of an electric current including usually the source of electric energy or an assemblage of electronic elements (Merriam-Webster Dictionary, 2003).

Focus Group — a small group of people whose response to something (as a new product or a politician's image) is studied to determine the response that can be expected from a larger population (Merriam-Webmaster Dictionary, 2003).

KSA's — abbreviation of knowledge, skills, and abilities. Knowledge refers to acquired information necessary to do the job, skills refer to acquired measurable behaviors, and abilities refer to natural talents or acquired dexterity (University of Washington, n.d.).

Laptop computer — a portable microcomputer having its main components (as processor, keyboard, and display screen) integrated into a single unit capable of battery-powered operation (Merriam-Webster Dictionary, 2003).

Likert Scale — a scale in which the respondent specifies a level of agreement or disagreement with statements that express a favorable or unfavorable attitude toward the concept under study (Quirk's Marketing Research Review, 2004).

Machine maintenance (M/M) — repairing and maintaining, in accordance with diagrams, sketches, operation manuals, and manufacturer's specifications, machinery and mechanical equipment, such as engines, motors, pneumatic tools, conveyor systems, and production machines and equipment, using handtools, power tools, and precision-measuring and testing instruments. (Dictionary of Occupational Titles (DOT) Index, n.d.).

Maintenance — to keep in an existing state (as of repair, efficiency, or validity): preserve from failure or decline <*maintain* machinery> (Merriam-Webster, 2004).

Manuals — contains the directions needed for using the resources in the total instructional system. The manual relates the purpose of the training, lists specific objectives, and tells the trainees what they will be doing at each step of the learning process (Craig, 1996).

Mitsubishi PLC program— name of software, used to solve electric problems at TTAI (http://www.mind.ne.jp/melsec-f/plc_fx/details/option/peripherals.htm).

On-the-job — of, relating to, or being something (as training or experience) learned, gained, or done while working at a job and often under supervision (Merriam-Webster Dictionary, 2003).

Programmable Logic Controller (PLC) — a programmable logic controller (PLC) uses programmed logic instructions to control banks of inputs and outputs which interface timed switch actuation to external electro-mechanical devices (Minarik Corporation, 2003).

Questionnaire —a document which contains questions that may be set down in a variety of formats: closed, open-ended, forced choice, priority listing (Buckley & Caple, 1990).

Repair— to restore by replacing a part or putting together what is torn or broken (Merriam-Webster Dictionary, 2003).

Secondary documents — data collected for some purpose other than the present research purpose (Momentum Research Group, 2003).

Software program —something used or associated with and usually contrasted with hardware as the entire set of programs, procedures, and related documentation associated with a system and especially a computer system; specifically **:** computer programs (Merriam-Webster Dictionary, 2003).

Troubleshoot — to locate and find the cause of problems related to technological

products or systems (Google, n.d.).

Toyota Production System — invented and promoted by Taiichi Ohno, former vice-

president of Toyota Motor Corp., for the purpose of "maintaining a continuous flow of

products in factories in order to flexibly adapt to demand changes" (Monden, 1983).

Training — instruction which emphasizes job-specific, near-transfer learning objectives;

traditionally skills-based instruction, as opposed to education (Wilson et al., 1993).

Chapter II

Literature Review

<u>Introduction</u>

The automotive industry is recognized as one of the most competitive businesses in the world. In such a competitive realm, Toyota's vehicle sales have seen a continued annual growth of four hundred thousand units, while major markets have been experiencing limited growth in recent years ("Toyota Corporate Information," n.d.).

Leverage of effective training is astonishing. As stated in the company mission statement, TTAI emphasizes continuous improvement in the fast growing automotive industry. If effective training is developed and implemented properly, the training will contribute to organizational success. To maximize training's impact on a business, the training manual needs to be developed based on thorough research with the elements that are highly recommended and supported by related literature.

Chapter two of this study will describe the elements of an instructional system, and the required background for understanding the principles underlying the procedures in developing effective training by introducing the Instructional Systems Development (ISD) model. The Instructional Systems Development (ISD) model was invented by the U.S. military as an efficient and effective way to train soldiers (Rothwell and Kazanas, 1998). ISD is a formal process for designing training, and the process includes analysis, design, development, implementation, and evaluation (Ehrlich , 2000). The keys to effective training outcomes are a systematically-developed instructional design and a systematically-implemented training delivery (Carkhuff & Fisher, 1984). There are several approaches to training such as Performance-Based Training (PBT) and Criterion

Referenced Instruction (CRI). However, ISD was chosen because this process provides

"a means for sound decision making to determine the who, what, when, where, why, and

how of training" that certainly describes everything about the training (Clark, 2002).

There are seven characteristics of using the ISD model for design of training (Nilson,

1992):

1. Approach design itself as a unique process with its own standards and
   controls.

2. Design efforts are systematic, with identifiable inputs and outputs and
   with system mandate to ask for, receive, and use feedback on design
   efforts.

3. Good design standards enable training developers to "get it right the first
   time" by correcting errors during the process of design so that training for
   customers is right the first time.

4. Good design leads learners efficiently through content.

5. Good design makes it easier for instructors to teach.

6. Good design gets learners to intended outcomes of training sooner.

7. Good design helps employees transfer what they learned during training to
   their jobs.

Thus, Instructional Systems Development (ISD) is considered to be one of the

most successful concepts when designing training in today's business context; therefore it

will be used in this study. The ISD model contains five steps as follows: Analyze,

Design, Develop, Implement, and Evaluate.

Analyze

The first phase of ISD starts with analysis of the situation to determine whether a performance problem stems from a lack of training or some other factors. Factors that cause performance deficiency, other than a lack of training, can be defective materials, poor equipment, conflicting procedures, poor supervision, inaccurate test equipment, poor lighting, overly restrictive specifications and poor design (Custer, 1986). The primary purpose of the analysis phase is to gather information on training needs, and to analyze training requirements. Training needs, the skills, knowledge, and ability that the target population does not have but that are necessary for them to perform in their current jobs, will be identified in this phase (Abella, 1986). The following four objectives need to be accomplished in the analysis phase: 1) determine the nature and symptoms of a performance problem and identify underlying causes, 2) clearly indicate the major functions, roles, tasks, and outcomes of a targeted job by identifying instructional sequence, prerequisites, equipment, and tools used and the acceptable standards of job performance, 3) specify the target audience for training and analyze its members' knowledge, skills, attitudes, and competencies to determine what they already know and what they need to learn to become fully proficient, 4) document the characteristics of the learning environment (Phillips & Ford,1996).

Design

Training design involves adapting the learning environment to maximize learning (DeSimon & Harris, 1998). Three key activities need to be carried out during the design phase: 1) determine performance objectives, 2) determine instructional methodologies, 3) structure and sequence program content (General Physics Corporation, n.d.). During the design phase, technical trainers formulate the training objectives, prepare the testing or

evaluation procedures, and create a training course specification list (Rothwell & Benkowski, 2002).

Performance objectives for the training will be formulated based on the training needs that are addressed in the Analysis phase. Objectives define what participants will be expected to learn as a result of participating in the HRD program (DeSimon & Harris, 1998). A goal is somewhat general, while an objective is measurable (Rothwell & Sredl, 1992). Training objectives clearly show what the training is intended to achieve, as well as specifying indicators of success (Bartram & Gibson, 2000). The acronym ABCD can be used as a reminder of the major components in the development of performance objectives statements (Craig, 1996):

1. Audience: describe the target population of learners.

2. Behavior: Specify the performance expected after the learning experience. Use action verbs to describe observable behavior. If necessary, clarify the relevant skill by adding a qualifying verb, e.g., "Demonstrate, by calculating according to the formula…."

3. Conditions: Describe the conditions under which the behavior is to be exhibited, including any resources given to or withheld from the learners. Describe the working environment under which the task will be performed. State what resources will be given or withheld, e.g., Can trainees use notes taken in class? What tools will they be working with? Job aids? Technical manuals?

4. Degree or standard: Specify the quantitative or qualitative criteria by which the performance will be judged. The standard may specify quantitative requirements, e.g., the number of steps that must be covered, the number of

features that output must contain, the minimum acceptable percent correct, or tolerances. Standards may specify qualitative requirement for the output, such as "smoothly," logically," or "as evaluated by experienced judges."

Instruction on how to deliver the training or what method to use in delivering the training will also be determined during the Design phase. Along with the criteria used to judge whether the performance objectives have been achieved, test development will take place in this phase as well.

Nilson (1992) presented three major training methods that include on-the-job training, independent or self-study, and group training. In selecting the training method, it is important to consider what the resources and constraints of the organization (time, money, people, and equipment) are in order to accomplish objectives (Craig, 1996).

On-the-job training (OJT) has several advantages over other training methods. Cadwell (1995) identified five advantages of OJT as follows: 1) a company that wants to train employees immediately would benefit from OJT since it requires minimal time to arrange classroom training. 2) Line managers are the only people who know the job well enough to train other employees, but they sometime lack skills for conducting formal classroom training; however, they work well in a one-on-one setting. 3) OJT eliminates the costs of transportation, lodging, food, and other expenses that often are associated with other types of training. 4) Employees are able to remain at their workstations during OJT, and they can continue to perform job responsibilities. 5) Training is more effective when learning takes place in the "real world" rather than in a simulated environment.

It is important to organize and sequence training content to achieve the best learning outcomes from trainees. The order in which the knowledge, skills, and abilities

will be taught is determined in the Design phase (Craig, 1996). Sequencing of the content should go from what is already known to what is not, from the easy to the difficult, from the concrete to the abstract (Custer, 1986).

Development

Training content is developed during the development phase. Content development utilizes the skill steps or task steps and knowledge required to achieve the training objectives (Carkhuff & Fisher, 1984). Training materials that will achieve the performance objectives is to produce the primary goal of the Development phase (Rothwell & Sredl, 1992). The actual products to be used in the teaching-learning process are created, at least, in prototype form (Craig, 1995). Elements that must be created in this phase include the following (Phillips & Ford, 1996):

- Course materials

- Learning activities

- Lesson plan and leader's guide

- Delivery system

- Tests or other evaluation materials.

Any materials that are required to support the performance objectives are developed in this phase. Course materials include books, training manuals, or videos to supplement learning. Learning activities include any exercises that will help the trainees learn the task. A lesson plan is an outline of important points of a lesson arranged in the order in which they are to be presented, including: (1) activities of the student and instructor, (2) specific points to be made, and (3) resources to be used, when, and how to use them. The lesson plan should be detailed enough so that instructors with similar

backgrounds can conduct the same course with a minimum of preparation while using the lesson plan (Google, n.d.).

Training delivery methods are selected based on many considerations. Some of the more important considerations are: 1) Course/performance objectives, 2) Needs of the trainees, 3) Instructor expertise, 4) Organizational policies, and 5) Organizational culture. Other considerations are cost, time, and learning effectiveness (Rothwell & Benkowski, 2003). Tapes, handouts, computers or videos can be used depending on the training.

Tests and other evaluation materials are also developed to determine the level of skills, knowledge, and ability that the trainees possess. There are two types of tests: knowledge-based (written or oral) tests, and performance-based (hands-on) tests. The knowledge-based tests include the following types of questions (Sullivan, et. al 1990):

- Multiple-choice

- True-false

- Matching

- Completion

- Essay

- Short-answer

All performance-based tests consist of process measurement or product measurement, or both. Process measurement involves the evaluation of the steps the learner goes through in order to perform the tasks, and product measurement consists of the evaluation of the final outcome of performing the task (Sullivan, et. al 1990).

Written tests are effective for assessing knowledge objectives, but not as effective for assessing the ability to apply that knowledge or evaluating the attainment of desired attitudes (Craig, 1996).

If on-the-job training is to be used, then trainers prepare lesson plans, checksheets, and other material for coaches or mentors to use at the work site (Rothwell & Benkowski, 2002).

<u>Implementation</u>

Training is delivered during the implementation phase. When conducting the training session, instructor should keep in mind the following nine instructional events to bring about successful training delivery (Gagne, et al., 1992):

1. Gaining attention from the participants

2. Informing the participants of the objective

3. Stimulating recall of prerequisite learning

4. Presenting the stimulus material

5. Providing learning guidance

6. Eliciting the performance

7. Providing feedback

8. Assessing the performance

9. Enhancing retention and transfer

It is also important to keep the participants motivated throughout the training session (Munson, 1992). Smile, use of humor, and being alive while conducting the training session will help capturing participants' interest, and will keep them motivated to

learn. The following practical suggestions are made by Munson to obtain the best understanding from the participants when implementing the training:

1. Use simple words

2. Communicate in small bites

3. Build on prior information

4. Go from the general to the specific

5. Break up complex ideas

6. State and restate

The effective use of support materials, trainee's positive posture, the proper use of hand gestures, body movements, facial expressions, and eye contacts, are also important considerations when conducting the training session (Chang, 1994).

Evaluation

The last step in the ISD process is Evaluation. Without a thorough evaluation of training programs, organizations cannot even begin to understand how to modify their programs to achieve the greatest effectiveness (Chrobot-Mason & Quinones, 2002). The purpose of evaluation is to improve the process, not rate the students (Gunter, 1996). The main objective for this final phase is to identify the impact of an intervention on individual or organizational effectiveness (Mclagan, 1989).

Kirkpatrick has developed a summative evaluation model that defines four levels of outcome measures (Medsker & Roberts 1992). The four levels represent a sequence of ways to evaluate programs, and none of the levels should be bypassed simply to get to the level that the trainer considers the most important (Kirkpatrick, 1994):

1. Reaction: Participant opinions regarding the training, its processes, and outcomes are measured. It is often described as customer satisfaction. The result of the reaction determines the motivation of the learner. Favorable reaction is preferred. Reaction involves comments and suggestions from the participants; therefore, it is useful in improving future programs. Reaction sheets provide quantitative information that is helpful in convincing managers and others how effective the training was.

2. Learning: The extent to which learning took place during the training with regard to knowledge, skills, and ability is measured. Use of paper-and-pencil test for knowledge and ability measurement and performance test for skills evaluation is recommended. The comparison of pre and post test results is effective in determining if learning has occurred.

3. Behavior: Changes in actual on-the-job performance will be measured to determine how much transfer of knowledge, skills, and abilities occurred due to participating in a training program. Intrinsic and extrinsic rewards need to be given to the employees who returned from the training to promote behavioral change. When to evaluate, how often to evaluate, and how to evaluate becomes critical in conducting behavior evaluation. It is important to allow time for behavior change to take place. Typically level three evaluations are measured three to six months after the trainings have been completed.

4. Results: The final results including increased production, improved quality, decreased costs, reduced frequency and/or severity of accidents, increased sales, reduced turnover, and higher profits and return on investment will be determined

in this level. The contribution made by a training program to the organization itself need to be clarified to determine what final results were accomplished because of the training program. It is very difficult but is important to measure the results repetitively at appropriate times to accomplish the evaluation successfully. Level four results are usually analyzed only after one year following the training.

This model is attributed to Dr. Donald Kirkpatrick, University of Wisconsin. It is supported by ASTD (American Society for Training & Development) and thousands of trainers (Medsker & Roberts, 1992).

The data from evaluation is fed back into the continuing organizational scan to determine changes in the actual performance of the workforce and to see if the actual performance approaches the desired performance, thus closing the performance gap (Rosenberg, 1996). Medsker and Roberts (1992) have identified several environmental contaminations that prevent training from boosting its effectiveness back in the workplace. Here are ten of the factors that influence how people perform at work (Medsker & Roberts, 1992):

1. relevancy of what was taught to what is needed to perform
2. immediacy of opportunity to apply
3. supportiveness of immediate supervisor of the learner
4. degree to which peers practice what the learner is trying to apply
5. time, money, and resources to support the new behavior
6. rewards and punishments that reinforce behavior (maintaining & correcting)
7. agreement of forms, equipment, procedures between workshop and workplace

8. culture that fosters the learner's long-range performance

9. workplace environment free of distractions, interruptions, and physical

   constraints

10. immediacy and specificity of feedback that lets employees know how they are

    doing

It is impossible to assume that the performance acquired through the training lasts long enough to be permanent, when trainees are faced with environmental obstacles such as those described above. Therefore, it becomes important to conduct evaluation at all four levels.

Summary

The review of the literature defined the structure of effective training manuals and their components that contribute to the success of training, and reviewed necessary elements to develop an effective training program. The literature review provided the information regarding the ADDIE model (most commonly used procedures for developing effective training programs). It also reviewed the four-level Kirkpatrick evaluation model.

The literature review indicated the benefits of a structured training program with detailed procedures to follow in analyzing, designing, developing, implementing, and evaluating the training prior to the program execution. This information supports the need for developing a training manual in the M/M department at TTAI. The application of the ISD model is encouraged for developing a training manual in M/M department at TTAI, as well as using the Kirkpatrick model to determine training program effectiveness.

Chapter III

Methodology

<u>Introduction</u>

The purpose of this study is to design and develop a standardized Mitsubishi

PLC program troubleshooting and repair training manual for TTAI Machine Maintenance

(M/M) personnel. This chapter will provide a description of the method used to develop

a standardized training manual for M/M members in TTAI, and will explain who will be

involved in determining the key topics for the training. Information relevant to

performance objectives, training topics, and training schedule will be collected using

personal communication and secondary documents.

<u>Survey Instrument</u>

The researcher will use a focus group and secondary documents to gather the

necessary data to complete this study. In the focus group, a total of twelve participants

will be brought together to discuss training related issues. The focus group meeting is

designed for the purpose of sharing insights, suggesting ideas, or making

recommendations on topics relevant to the Mitsubishi PLC program troubleshooting and

repair training. Since a focus group is a qualitative research technique, the researcher

will record participants ideas and opinions during the meeting. Collected data will then

be combined and reviewed by the participants at the end of each meeting.

The Machine Maintenance (M/M) department in TTAI obtains data from skills

assessments to determine the level of skills that each member possesses. The results of

the assessments are used for training purposes. Once the data from each member is

collected, it will be entered on a skills checkup flowchart (Appendix A) that contains the

names of all the M/M members and necessary competencies required to repair and maintain welding and stamping machines. Based on the approval of all the group leaders, Japanese supporters, and a manager in the M/M department, each competency box corresponding to each member will be checked in three month intervals. The M/M members with skill deficiencies in using the Mitsubishi PLC program will be identified on the skill checkup flowchart (Appendix A).

There are many data collection methods such as an interview, survey, observation, or questionnaire; however, focus groups and secondary documents were selected from these methods to minimize the interference with production time.

Participants

There is one manager, two group leaders (one from the day shift, and the other from the night shift), six team leaders (three from each shift), and three Japanese supporters (two from the day shift, and one from the night shift) in the M/M department in TTAI. Participants are comprised of males whose ages vary from 25 to 48 years. Two focus group meetings will be held separately for the day shift and the night shift to collect information related to training on Mitsubishi PLC program. The twelve focus group participants will determine what topics to include in the Mitsubishi PLC program training manual, who will participate in the training, which performance objectives to train on, and the training schedule. All twelve participants will be informed about this research prior to the focus group meeting to determine the most appropriate key issues. A memo will be distributed to these twelve people three days before the designated meeting, thus giving them time to consider what they might want to propose during the meeting. The focus group meeting will be held separately from the day and the night shift to minimize

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interference with production time. Notes will be taken for the purpose of data collection during the meeting.

During the data gathering process, these twelve M/M members will be given an opportunity to freely speak about their concerns on the use of Mitsubishi PLC program in electrical troubleshooting. The researcher will take notes on issues addressed during the meeting, and will have them reviewed by all the participants in the end of the meeting.

Summary

This Chapter covers the methodology used in determining the key topics of the Mitsubishi PLC program training manual, the members who will participate in the training, which performance objectives to train on, and the training schedule. Areas that are prominent in skill deficiency regarding the Mitsubishi PLC program among M/M members will be identified, and the training topics, the schedule, and the performance objectives will be finalized by the end of the information gathering process.

Chapter IV

Results

<u>Introduction</u>

The purpose of this study was to design and develop a standardized Mitsubishi PLC program troubleshooting and repair training manual for TTAI Machine Maintenance (M/M) personnel. Determination of training topics, schedule, and performance objectives were necessary elements to complete this study. The data were collected from focus group meetings that were held in the M/M department on February 16, 2004. The skills checkup flowchart (Appendix A), was used during these sessions to collect the data. Data were collected from and confirmed by twelve people: one M/M manager, two group leaders, six team leaders, and three Japanese supporters. Their purpose was to determine the key topics, performance objectives, and the schedule that needed to be included in the standardized Mitsubishi PLC program troubleshooting and repair training manual for TTAI M/M personnel. The performance objectives were determined for the purpose of keeping trainees and trainers focused on what to achieve during the training.

This Chapter will present the selected topics determined by the twelve people who participated in the focus group meetings for the Mitsubishi PLC program training. The course schedule and training activities that were developed during the focus group meeting will also be presented.

<u>Findings and Results</u>

There are thirty-three members in the M/M department of TTAI. Twelve of these members are more experienced and possess greater troubleshooting and repair expertise. These twelve members were selected to be the focus group for this study. There were

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twelve other M/M members who were newly hired and lacked KSA in using the Mitsubishi PLC program. They will become the students when training is conducted.

The focus group determined four major topics to include in the training manual:

1. Understanding of Electrical Ladder Symbols

2. Understanding of Mitsubishi PLC Program Functions

3. Basic of electrical circuit programming

    a. Set up Mitsubishi PLC Program

    b. Screen Circuit Diagram

        (1) Read PC

        (2) Read ladders

    c. Monitor Screen Pause

    d. Forced Output

    e. Remote Run

    f. Remote Pause

    g. Remote Stop

    h. End laptop program

4. Applied electrical circuit programming

    a. Modify ladder diagram

        (1) Delete Circuit

        (2) Change Mode

    b. Save ladder programs

    c. Transfer of Program

    d. Create New Ladder Program

Rothwell and Benkowski's (2002) guideline on creating training curriculum was used to clarify and validate the training content. The guideline is presented in Appendix B. The purpose of this troubleshooting manual is to enable participants to acquire skills necessary to troubleshoot electrical problems of machines installed in TTAI, using the Mitsubishi PLC program.

The performance objectives define what the training participants should know or do upon completion of the course. After determining the training topics, the following four performance objectives were developed:

1. Given ladder symbols printed on a paper, participants should be able to: a. Name each function of the symbol. b. Describe the difference of each symbol. c. Identify all the symbols provided on a given paper.

2. Given a sheet of paper and a laptop computer installed with Mitsubishi PLC program, participants should be able to: a. List the functions of Mitsubishi PLC program on the paper, b. Explain the function accordingly to the list they provided, c. Demonstrate the function accordingly to the list they were provided.

3. Given a laptop computer installed with Mitsubishi PLC program, participants should be able to: a. Set up the program. b. Demonstrate how to read ladder programs. c. Demonstrate how to modify the ladder program.

4. Given a laptop computer installed with Mitsubishi PLC program, participants should be able to: a. Demonstrate accordingly to what the trainer request on electrical circuit programming. b. Demonstrate how to save the program. c.

Demonstrate how to create new program. d. Demonstrate how to transfer program to the connected devices.

The course participants will be members in the M/M Department who were identified on the skills checkup flowchart (Appendix A) with skill deficiencies in using the Mitsubishi PLC program to solve electrical problems. Course prerequisites include previous experience in using a laptop computer, experience in machine repair, maintenance, or troubleshooting, and knowledge of electrical circuit repair. All the prerequisites are part of required KSA's that were identified prior to their employment in the job interview; therefore, all the members in M/M at TTAI possess these KSA's. Those M/M department members identified with electrical troubleshooting skill deficiencies were those who were newly employed in the past twelve months.

The training will be delivered at the workshop next to the M/M office in TTAI. Because the Mitsubishi PLC program needs to be connected to the machines in order to activate the program, this training will be delivered on-the-job. A total of three sessions that consist of four hours a day will be delivered to each member.

The instructor for this training course is a Japanese supporter who is assigned to work with employee training at TTAI. Approximately three supporters visit TTAI for a three month interval. Most of the time, these supporters are in a group leader's position back in the Japanese plant. They are chosen for the group leader's position based on their experience, evaluation from both the manager and the peers, and the scores from a leadership test.

With the topics and objectives agreed upon, the training schedule was determined. The course schedule was developed in collaboration with Japanese supporters who will conduct the training to selected M/M members in TTAI, and is presented in Appendix C.

<u>Summary</u>

This Chapter presented the findings and results from the meeting and the skills assessments flowchart (Appendix A). Data were gathered to identify key topics, targeted population for the training, performance objectives, and the schedule. The researcher used a focus group to determine the design of the training format and the content of the training manual. The focus group meeting determined four main topics with twelve subtopics that needs to be covered in the training. Twelve members from machine maintenance department who were hired in the past twelve months were identified with skill deficiencies in utilizing the Mitsubishi PLC program. Based on the training topics selected during the meeting, and the skills checkup flowchart (Appendix A), the training schedule and four primary performance objectives.

Chapter V

Discussion

<u>Summary</u>

The purpose of this Chapter is to present the summary, conclusions, and recommendations. The Mitsubishi PLC program troubleshooting and repair training manual was designed and developed for the purpose of enhancing participants effective troubleshooting skills. A standardized training manual, including four performance objectives and a three day training schedule of four hours per day was designed and developed based on focus group meetings held in Machine Maintenance (M/M) department at TTAI. Twelve members in the M/M department at TTAI were identified with skill deficiencies in using the Mitsubishi PLC program, and they will be the trainees of the Mitsubishi PLC training program.

<u>Conclusions</u>

The purpose of the focus group meetings held on February 16, 2004 at the Machine Maintenance Department in TTAI, was to gather necessary information related to the Mitsubishi PLC training program. It brought great awareness to the people who attended the meetings of the importance of standardizing the training program. The twelve focus group participants will be in a position to directly influence the other M/M members; therefore, it is anticipated that they will create a positive environment for trainees to actively participate in the training. They will also ensure that the twelve participants will apply their newly learned skills back on the job.

<u>Recommendations</u>

The primary purpose of this study was to design and develop a standardized training manual for the Machine Maintenance Department at TTAI. There are five phases in the process of designing training: analysis, design, development, implementation, and evaluation.

In this study, the researcher completed the analysis, design, and development phases. However, it is important to note that implementation and evaluation are necessary to accomplish organizational success.

The literature review in Chapter two indicated that conducting appropriate evaluation, in an appropriate time frame, is fundamental to accomplishing the training objectives. While this study did not address the evaluation phase, it is highly recommended that TTAI create and implement some form of summative evaluation after conducting the training, based on the Kirkpatrick's four-level evaluation model.

Evaluating the effectiveness of training is an important component; therefore, it is necessary to create a measurement tool of training outcomes based on the Kirkpatrick's four-level evaluation model.

As previously noted in Chapter II, there are four levels of training evaluation including reaction, learning, behavior, and results (Kirkpatrick, 1994). In the reaction phase (level-I), the use of a questionnaire is suggested in measuring the reaction of the trainees toward the training. Reaction needs to be measured immediately after the training so that the information gathered will be accurate. By conducting a survey for the training, the trainer will be able to determine if the trainees are satisfied with the course. Sample questions and format are shown below (Kirkpatrick, 1994):

Please indicate a rating for each statement below by circling a number on the

scale to the right:

<pre>
                                    Strongly   Strongly
                                    Agree   Disagree
                                    l----------l----------l----------l----------l
                                    5   4   3   2   1
</pre>

1) The material covered in the program
    was relevant to my job:

<pre>
                                    l----------l----------l----------l----------l
                                    5   4   3   2   1
</pre>

2) The material was presented in
    an interesting way:

<pre>
                                    l----------l----------l----------l----------l
                                    5   4   3   2   1
</pre>

3) The instructor was well prepared:

<pre>
                                    l----------l----------l----------l----------l
                                    5   4   3   2   1
</pre>

4) The schedule was suitable:

<pre>
                                    l----------l----------l----------l----------l
                                    5   4   3   2   1
</pre>

When evaluating learning (level-II), it is important that all students participate. Kirkpatrick (1994) suggests the use of a paper-and-pencil test to measure knowledge, and a performance test to measure skills and ability. In this study, the researcher designed a training schedule that includes pre and post test; therefore, comparison of the score from pre and post test will indicate how much the trainees learned from the training course. The result of the learning evaluation will provide information relevant to trainee's acquisition in KSA's, and also an effectiveness of trainers as an instructor. For this study, Japanese supporters are responsible for creating a pre and post test for the level II evaluation because they are the subject matter experts and will be providing training to the M/M members.

Evaluating on the job behavior (level-III) is necessary to make sure KSA's learned in the training program transfer to the job. Conducting a survey or interview on trainees or their immediate supervisor is recommended to find out if trainees are actually using the KSA's gained from the training. As is mentioned in Chapter three of this study, the M/M Department at TTAI maintains a skills checkup flowchart (Appendix A) for each M/M member.   Because the skills checkup flowchart (Appendix A) is reviewed in three month intervals and it identifies M/M members' KSA's, it can be used as a behavior evaluation.

Lastly, organizational impact (level-IV) needs to be measured to find out if attendance and participation in a training program has caused organizational improvement. Down time of machines directly influences production volume. Being able to use the Mitsubishi PLC program gives another option to approach and resolve machine breakdown problems. Giving more options to approach machinery problems will help reduce down time by figuring out the causes and repairing them faster, therefore, it will influence productivity. Machine Maintenance members at TTAI are required to keep records of repair reports every time they repair machine deficiencies. These reports will be put into a database to generate charts and graphs showing the performance of the M/M department on a weekly basis. This data can be a helpful tool to evaluate organizational impact by comparing the results on an annual basis.

The Mitsubishi PLC program training manual will benefit the M/M Department at TTAI when conducting the training, because it helps clarify the who, what, when, where, why, and how of training. This manual will also eliminate unnecessary time and effort spent by translators during training. Hence, it is anticipated that the standardized training

manual that was designed and developed in this study will enhance the effectiveness of

training, and will contribute to TTAI's organizational success.

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Appendix A: Skills Checkup Flowchart

*	Load & read Mitsubishi PLC program using laptop computer	Monitor PLC program, Mitsubishi	Update & copy all PLC programs	Print hard copy	Jump out necessary contact in the program	Hard wire relay circuit. Minimum 5 relays.	Adjust read switch	Hard wire relay latch circuit	Change relay
A									
B									
C									
D									
E									
F									
G									
H									
I									
J									
K									
L									
M									
N									
O									
P									
Q									
R									
S									

* Employees' name appears on the left most row.

*	Write a new Mitsubishi program	Change out PLC card	Understand addressing of inputs/outputs, all PLC	Write program modification to individual equipment	Hard wire circuit and program PLC as necessary	Install light curtain & interlock to machine	Hard wire timer & add to PLC program
A							
B							
C							
D							
E							
F							
G							
H							
I							
J							
K							
L							
M							
N							
O							
P							
Q							
R							
S							

* Employees' name appears on the left most row.

*	Install weld timer	Monitor links system	Read & write to all in-house PLC's CQM 1, CPM 1A, H200E, AOJ, A2, A3, FX, A1S, etc.	Install PLC and program
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				

* Employees' name appears on the left most row.

Appendix B: Guideline on creating training curriculum (Rothwell & Benkowski, 2003)
EXHIBIT 6.2.   COURSE DESCRIPTIONS LINKED TO THE TRAINING CURRICULUM

Directions: Answer the questions appearing below for each course listed on the organization's training curriculum.

1. What is the purpose of the course? State the purpose of the course in one sentence.

2. What should participants in the course know or do upon course completion? (In other words, what should they know how to do upon course completion that they did not know when the course began?) List three to five instructional objectives for each course. Use this format for each course:

    Example:

    Given a book describing Deming's philosophy, participants should be able to:

    1. Identify the fourteen points
    2. Describe how the fourteen points apply to Company X's equipment
    3. Describe how the fourteen points apply to their departments/jobs

3. Who are the targeted participants? (Describe, as specifically as possible, who should take the training and at what point in their period of employment they should take it and why. Specify course prerequisites.)

4. How should the course be delivered? (Describe the way the course is presented to participants. Examples of appropriate answers would include "Two-day classroom-based course.")

5. (**If applicable**) Who should be the instructors, if the course is to be instructor-led? (Describe, as specifically as possible, the instructors' essential training, education, and/or experience that makes them qualified to teach—and could disqualify those who are not qualified to teach the course.)

6. What is the course content? (Provide a topical outline for each course. Use about half a page for each outline to describe course content. Add paper as necessary.)

7. How should the course be evaluated? (Answer these questions: Should participants complete course evaluations? Should participants complete pre-/post-tests to measure their knowledge? Should participants complete six-month post-course evaluations to measure on-the-job learning transfer? Should efforts be made to measure the return on training investments by indicating long-term productivity gains to be realized by the training? Should instructors rate participants, course, and/or other issues?

Appendix C: Training Schedule

First Day

- 09:00 – 09:40 Pre-Test on Electrical Ladder Symbols, functions of Mitsubishi

  Sequencer PHP, basic of Electrical Circuit Program, and applied

  Electrical Circuit Program

- 09:40 – 10:15 Grade and review the pre-test

- 10:15 – 11:00 Lunch break for the 1st shift

- 11:00 – 12:00 Electrical Ladder Symbols and Mitsubishi Sequencer PHP

  program functions

- 12:00 – 1:15 Regular work schedule

- 1:15 – 2:00 Basic of Electrical Circuit Program

  - o Set up PHP

  - o Screen Circuit Diagram

  - o Monitor Screen Pause

- 2:00 – 2:15 Break

- 2:15 – 3:15 Basic of Electrical Circuit Program continue

  - o Forced Output

  - o Remote Run

- 3:15 First Session End

Second Day

- 09:00 – 09:40 Review from the last lesson

- 09:40 – 10:15 Basic of Electrical Circuit Program Continue

    o   Remote Pause

- 10:15 – 11:00 Lunch break for the 1st shift

- 11:00 – 12:00 Basic of Electrical Circuit Program Continue

    o   Remote Stop

    o   End Laptop Program

- 12:00 – 1:15   Regular work schedule including 15 minutes break

- 1:15 – 2:00   Applied electrical circuit programming

    o   Modify Ladder Diagram

        ▪ Delete Circuit

        ▪ Change Mode

- 2:00 – 2:15   Break

- 2:15 – 3:15   Applied electrical circuit programming continue

    o   Save ladder program

    o   Transfer of ladder program

- 3:15   Second Session End

Third Day

- 09:00 – 09:40 Review from the first lesson

- 09:40 – 10:15 Review from the second lesson

- 10:15 – 11:00 Lunch break for the 1st shift

- 11:00 – 12:00 Applied electrical circuit programming

- 12:00 – 1:15 Regular work schedule including 15 minutes break

- 1:15 – 2:00   Applied electrical circuit programming

    o   Create New Ladder Program

- 2:00 – 2:15   Break

- 2:15 – 3:00   Post Test

- 3:00 – 3:15   Evaluation for the training program

- 3:15   Final Session End