



AN ABSTRACT OF THE THESIS OF

Lindsay M. Wiseman for the degree of Master of Science in Industrial Engineering presented on May 31, 2011

Title: Evaluating the Effectiveness and Efficiency of Continuous Improvement Training

Abstract approved:

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Toni L. Doolen

Training is a key business process used to increase the skills and knowledge of employees in an effort to improve overall performance. Evaluation of the effectiveness and efficiency of training processes is necessary to ensure time, money, and resources are used to provide the most benefit possible. This investigation is aimed at understanding what relationship, if any, exist between time, communication, and resources utilized throughout the training to the overall effectiveness and efficiency of training events when introducing continuous improvement tools in an organization. The understanding of what variables impact the effectiveness and efficiency can be used to improve training materials and processes.

The results from regression models support the importance of resources on both training effectiveness and efficiency. These results suggests that the trainer should focus on evaluating their contribution in assisting trainees during training, as well as the impact of training materials and tools. In addition, the time allotted to training and the time spent during training for explanation and practice should be carefully evaluated and modified to best meet learning

outcomes. The findings from this research can be used to assist trainers and managers in designing continuous improvement training programs. Managers should not underestimate the importance of creating an environment in which continuous improvement tools can be successfully applied in an organization. Ultimately, the findings of this study emphasize the value and need for trainers and managers to pay attention to improving and adapting training just as they must to other key business processes.

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Evaluating the Effectiveness and Efficiency of Continuous Improvement Training

by

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Lindsay M. Wiseman, Author

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## **1 Introduction**

While there is substantial literature devoted to evaluating the effectiveness of training and effects of lean implementations, there is a need for research evaluating the effectiveness and efficiency of training in support of lean implementation in organizations. This thesis will develop and test a framework for an evaluation approach that can be modified by organizations and researchers to quantitatively evaluate training programs used in support of lean implementation activities. The results of this study will help confirm what relationships, if any, exists between time, communication, and resources utilized throughout the training to the overall effectiveness and efficiency of training for a given organization. The literature from the engineering management and lean manufacturing bodies of knowledge was used to form the framework.

This chapter introduces the motivation for this research, contribution of this research, research objectives, methodology used, and conclusions.

### **1.1 Motivation**

Organizations are required to adapt in order to meet changing market demands. This adaptation can be achieved through a variety of means, such as employee development, changes to production planning, or shifts in management structure. These approaches to change focus on introducing employees to ideas and technologies that will keep an organization competitive. A standard method to improve the current skills of employees and to help employees develop new skills is training (Forsyth, 2006; M. L. Moore & Dutton, 1978).

An industry report in 1995 showed that 57% of training is focused on problem solving skills (Farr & Sullivan Jr., 1996). The use of problem solving training has rapidly increased as the

concepts centered on continuous improvement (CI) have become a standard across a variety of industries. CI is defined by B. S. Scott, Wilcock, & Kanetkar (2009, p. 209) as

A systemic approach to the measurement, analysis, and improvement of business processes to identify critical areas that can produce breakthrough results in market penetration, product quality attributes, quality assurance and/or manufacturing processes, customer satisfaction, cycle time and/or the cost of doing business.

CI can be implemented using a wide variety of tools and concepts. These tools and concepts include, but are not limited to 5S, Kaizen, Just-in-Time, elimination of the seven deadly wastes, value stream mapping, Plan–Do–Check–Act (PDCA) cycle, cause and effect diagrams, fishbone analyses, and brainstorming (Álvarez, Calvo, Peña, & Domingo, 2009; Bagadia, 2008; Jorgensen & Kofoed, 2007; Liker & J. M. Morgan, 2006; Scott et al., 2009; Womack, D. T. Jones, & Roos, 2007).

Previous research has focused on evaluating CI once a program has been fully developed and implemented for a period of time sufficient enough to allow for noticeable changes to be seen in an organizations' key performance indicators, such as downtime, number of defects, cycle time, percent utilization, levels of inventory (Álvarez et al., 2009; Bayou & De Korvin, 2008; Bonavia & Marin, 2006; Furterer & Elshennawy, 2005; Harrison, Haug, G. H. Baker, & G. L. Moore, 1997; Palo & Padhi, 2003; Slomp, Bokhorst, & Molleman, 2005; Tuai, 2006; Villarreal, Garcia, & Rosas, 2009). Before an organization can start implementing lean concepts throughout the organization, training must be deployed.

This training should be customized to be appropriate for the current culture of the organization and should also be updated as the company matures in its utilization of lean tools (Atkinson, 2010). The traditional focus when implementing lean concepts has been set on training employees on lean tools and a lean framework. The next step of building a lean organization is to focus on managing the softer aspects such as “building the energy and engagement of employees from the shop floor and the office pool upward, tapping into their ideas, focusing employees on problem solving, and keeping employees open to change and flexibility” (Liker & J. M. Morgan, 2006, p. 6).

Evaluation of training must occur to ensure consistency in the training. Evaluation criteria must be customized and focused on the priorities of the organizations, e.g., time, money, and employee morale, and be used consistently. Feedback from training evaluations can help the organization improve the likelihood that continuous improvement efforts will be successful by understanding the various aspects that shape a successful training session. Evaluating training is essential to ensuring that there is employee buy-in and in helping the organization focus energy where it is most needed (Jorgensen & Kofoed, 2007; Kuprenas, Haraga, DeChambeau, & Smith, 2000).

This study specifically looks at evaluating both the effectiveness and efficiency of training. The evaluation of the effectiveness of a training program focuses on ensuring the employees are able to apply the new knowledge as soon as possible. The evaluation of the efficiency of training will contribute to the body of knowledge as training efficiency is currently not well studied. Overall,

the evaluation of the efficiency of a training program ensures that the effort and resources put forth are making the greatest impact. The results from an evaluation of training efficiency will help an organization continuously improve its training programs.

The motivation for this research came after researchers from Oregon State University were asked to develop training to implement continuous improvement tools tailored to a steel manufacturer. An example of a continuous improvement training presentation can be seen in Appendix G. The goal of the training system was to help the organization transition from a product-focused quality assessment system to a process-oriented quality management system, consistent with ISO 9001. The anticipated results of implementing these continuous improvement tools was increased quality, reduced scrapped material, and increased productivity, which would improve the organization's overall competitiveness. The success of the training was important in ensuring the successful implementation of continuous improvement activities across multiple functional departments in the study organization. The development of this training led to the researchers questioning various aspects of the training program: Who should be included in the training? How can the effectiveness of training be improved as the training is deployed? How can the efficiency of the training be evaluated? Is the process of evaluating continuous improvement training different than evaluating other types of employee training, e.g. safety training or job training? These questions became motivation to understand the various elements that contribute to a successful creation and effective evaluation of training events.

### *1.1.1 Contribution*

This research contributes to both existing literature on training effectiveness and is also relevant to practicing engineering managers about to engage in the implementation of continuous improvement practices. The main objective of this project was to evaluate various continuous improvement training events in the target organization. This evaluation was focused on determining ways to shape the training to best fit the current culture. The research was also structured to understand what relationship, if any, existed between time, communication, and resources utilized to the overall effectiveness and efficiency of training events. Understanding what factors impact the effectiveness and efficiency can be used when developing future training events. Ultimately, findings from this study may be helpful for other organizations developing or modifying continuous improvement training events.

### *1.1.2 Contributions to the Literature*

Previous research on training has focused largely on providing guidelines for evaluating the effectiveness of traditional training sessions (Aguinis & Kraiger, 2009; Bell & Grushecky, 2006; Berge, 2008; Brethower & Rummler, 1979; Farr & Sullivan Jr., 1996; Fraser, 2008; Galanou & Priporas, 2009; Gilpin-Jackson & Bushe, 2007; Goldstein, 1980; Hequet, 1993; Kumpikaitè, 2007; Kuprenas et al., 2000; Lim, 2009; Louati, Boudabbous, & Bouzguenda, 2010; Marentette, Johnson, & Mills, 2009; Matson & Stauffer, 2009; McCloskey, 2002; Misko, Halliday-Wynes, & National Centre for Vocational Education Research, 2009; Nickols, 2000; Noe & Schmitt, 1986; Ostroff, 1991; Palo & Padhi, 2003; Parry, 1997; Poulet, 1986; Rowden, 2005; Schmeckle, 2003; Schmidt, 1970; Shukla-Mehta, Miller, & Callahan, 2010; Siniscalchi, Beale, & Fortuna, 2008; Tudor, 1994). Traditional training sessions typically occur in classroom settings and focus

on teaching employees specific skills using lectures, videos, and/or PowerPoint presentations. The material used during traditional training sessions is often preset, i.e. not adapted for specific types of employees or specific work areas (Farr & Sullivan Jr., 1996; Miyamoto, 1991).

This research extends beyond previous research by identifying criteria to evaluate both the effectiveness and efficiency of training. This evaluation adds to the limited number of studies focused on the theoretical and empirical analysis of training (Goldstein, 1980). In addition, the criteria was developed to be applicable to training sessions that were not necessarily occurring at a scheduled time in a classroom and to training sessions that focused on both individual and team development. Another contribution to the existing literature is the testing of the validity of the evaluation criteria in the field.

### *1.1.3 Contribution to Practicing Engineering Managers*

An industrial engineer can be defined as

one who is concerned with the design, installation, and improvement of integrated systems of people, material, information, equipment, and energy by drawing upon specialized knowledge and skills in mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems (Salvendy, 2001, p. 5)

More recently industrial engineers are asked to improve all types of processes critical to the competitiveness of an organization. In addition, industrial engineering managers are often given the role of leading an organization's CI activities. Thus, it is appropriate that this research is targeting the identification of criteria relations to improving CI training. The criteria identified as a result of this research can be used by engineering managers to identify opportunities for

improving both the effectiveness and efficiency of an organization's training processes. The criteria, if used by managers, can also help managers increase buy-in from employees and prevent negative perceptions about training and CI implementation. This can be done by ensuring that the tools, concepts, and training methods are well-suited to the needs of the organization and to the target audience for each training session.

## 1.2 Research Objectives

The objective of this research is to not only create an evaluation criterion specific to continuous improvement training, but to also determine whether or not significant relationships exist between time, resources, communication and effectiveness and/or efficiency. A thorough survey of the literature on training was used to identify these variables. The results of this research will be beneficial to any researcher or trainer within an organization which chooses to customize the research survey to specific objectives. The objectives for this research are summarized in Table 1.1.

Table 1-1 Research Objectives

1. Develop a method to quantitatively evaluate the effectiveness and efficiency of a training program.
2. Determine what factors correlate to the effectiveness of employee training as it pertains to CI implementation. <ol style="list-style-type: none"> <li>a. Determine what, if any, relationship exists between time and effectiveness.</li> <li>b. Determine what, if any, relationship exists between resources and effectiveness.</li> <li>c. Determine what, if any, relationship exists between communication and effectiveness.</li> <li>d. Determine what, if any, relationship exists between time, communication, resources, and effectiveness.</li> </ol>
3. Determine what factors correlate to the efficiency of employee training as it pertains to CI implementation. <ol style="list-style-type: none"> <li>a. Determine what, if any, relationship exists between time and efficiency.</li> <li>b. Determine what, if any, relationship exists between resources and efficiency.</li> <li>c. Determine what, if any, relationship exists between communication and efficiency.</li> <li>d. Determine what, if any, relationship exists between time, communication, resources, and efficiency.</li> </ol>

### 1.3 Methodology

A survey of the literature was conducted to understand existing approaches for evaluating training. The literature review findings were synthesized and used to create the basic framework used for this study. Alongside the survey of the literature, a field study was conducted at a study organization in the initial stages of introducing employees to continuous improvement concepts and tools using both formal and informal training events.

An evaluation criterion was developed from the compilation of the survey of the literature and the field study. The independent variables identified were time, resources, and communication. The dependent variables for the study were the effectiveness and efficiency of the training. Survey items for each of these variables were then assigned a code, randomly arranged and a

survey was designed. Two surveys were created. Survey A was used to evaluate events leading up to the training event, as well as evaluating the training event. Survey B was created to evaluate the impact of the training two or more weeks after a participant had completed the training.

The survey statements were formatted using a 5-point Likert Scale. The scale values used were as follows;

- 1 = Strongly Disagree
- 2 = Disagree
- 3 = Neutral
- 4 = Agree
- 5 = Strongly Agree

The survey was distributed to employees who had completed any form of CI training. No personal information was gathered about the specific employees to maintain anonymity. Surveys were returned into a locked box accessible to all employees all hours of the day.

After all data was synthesized, internal reliability for each variable was checked to determine if any survey items should be removed from the analyses. Two scales were modified as a result of this analysis. Linear regression was used to test the relationship between each independent and dependent variable. An Analysis of Variance (ANOVA) was completed to test for differences between various groups of individuals. Multiple regression analysis was used to identify the most significant independent variables in explaining variation in training effectiveness and efficiency. Assumptions for the various models were checked prior to analysis.

#### 1.4 Conclusions

The results showed there was evidence of a direct relationship between all three independent variables and effectiveness, shown in Figure 1-1. The results suggest that trainees believe that the influence of the trainer and tools is very important to the delivery of effective continuous improvement training. The relationship between communication and effectiveness suggests that managers and trainers should communicate expectations before training. Trainers should also continue to communicate with managers and trainees after the training is complete. Time had the smallest effect on effectiveness of the three tested variables. However, a significant relationship was found, and thus supports the importance of allocating sufficient time for both explanation and practice, if an effective training session is desired.

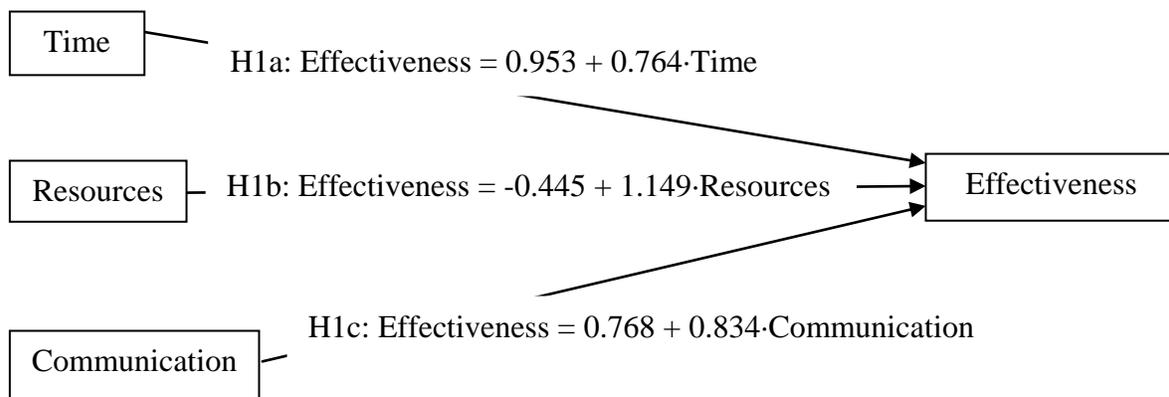


Figure 1-1 Analysis Results for Hypothesis H1

Similar to Hypothesis 1, all three independent variables showed a direct relationship with efficiency, as shown in Figure 1-2. Similar to Hypothesis 1b, the results for Hypothesis H2b suggest that the trainees believed that both the trainer and tools play an important role in training efficiency. The training was efficient when the material provided was easy to follow and well

explained by the trainer. The relationship between communication and efficiency was also seen as important. The impact of communication implies trainers should give clear explanations throughout the training and that managers and trainers trainees should communicate objectives and expectation to trainees before training. Time had a direct relationship to efficiency as well.

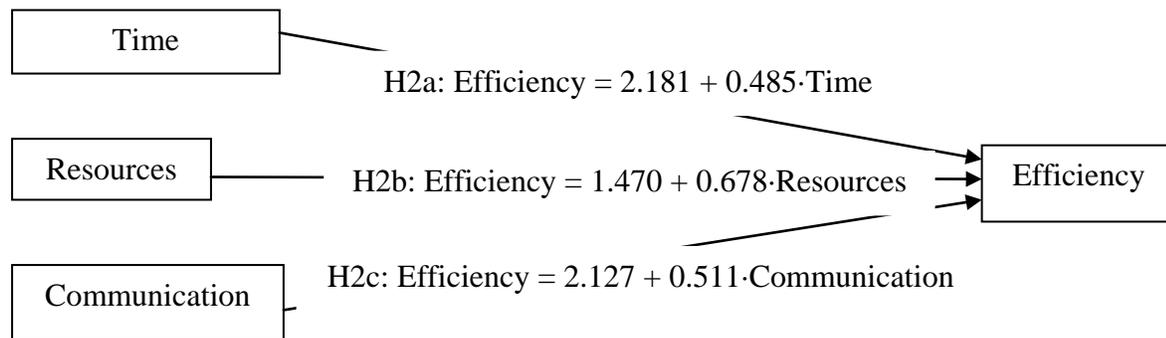


Figure 1-2 Analysis Results for Hypothesis H2

The results from both the linear and multiple regression models support the importance of resources on both training effectiveness and efficiency, as shown in Figure 1-3. This suggests that the trainer should focus on evaluating their contribution in assisting trainees during training, as well as the impact of training materials, tools used to assist throughout the session, and any additional material used. In addition, the time allotted during training and time spent during training for explanation and practicing should be carefully evaluated and modified to best meet the training session's learning outcomes.

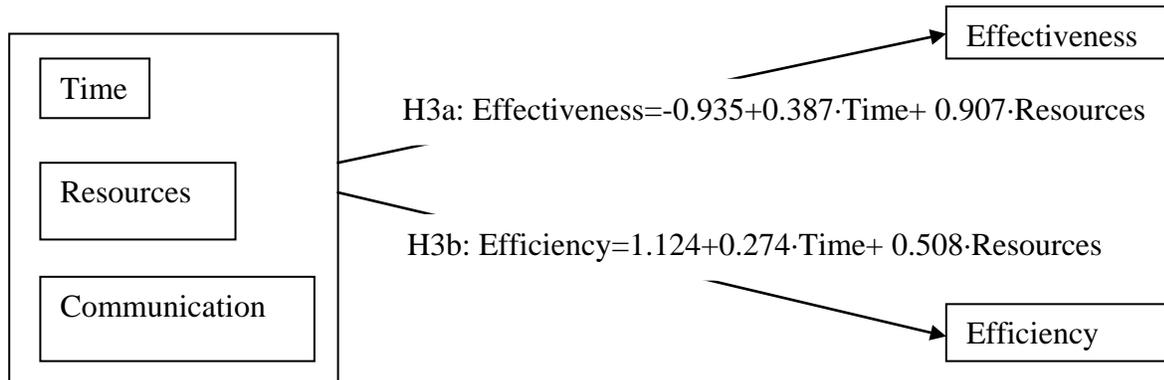


Figure 1-3 Analysis Results for Hypothesis H3

The findings from this study contribute empirical evidence and an evaluation methodology of training effectiveness and efficiency to the current training literature. The methodology and tools presented in this research provide a template that can be used to assist managers and trainers in conducting an assessment of both before initiating training as well as an evaluation assessment for established CI training.

Findings from this study conclude that trainers should evaluate their performance to ensure that they were efficient with their use of time and that their presentations are helpful to trainees. Similarly, managers should not underestimate the contributing role that they place in assisting employees with the implementation of continuous improvement tools in the work environment.

The findings from this research can assist trainers and managers in gaining a better understanding of the additional complexities that must be accounted for when designing continuous improvement training programs to fit a particular organizational current culture. Managers must understand the importance of creating a successful continuous improvement

training programs in creating an environment in which CI tools can be successfully applied throughout an organization. Ultimately, the findings of this study emphasize the value and need for trainers and managers to pay attention to improving and adapting training just as they must to other key business processes.

## 2 Literature Review

The literature reviewed for this study was specifically chosen for its content. Previous research reviewed included studies focused on evaluating training and/or the use of lean tools in organizations. More specifically, previous research on evaluating training, implementing training, evaluating effectiveness of training, evaluating efficiency of training, and implementing continuous improvement was included in this review.

### 2.1 Literature Review Model

The literature reviewed for this study is divided into three main research areas: training, continuous improvement (CI), and evaluating effectiveness and efficiency of a system, as seen in Figure 2-1. Much of the literature reviewed touched on more than one of these research topics. The three main overlapping research areas included: CI training, evaluating continuous improvement, and evaluating training. The literature reviewed focused on bringing together all three research areas.

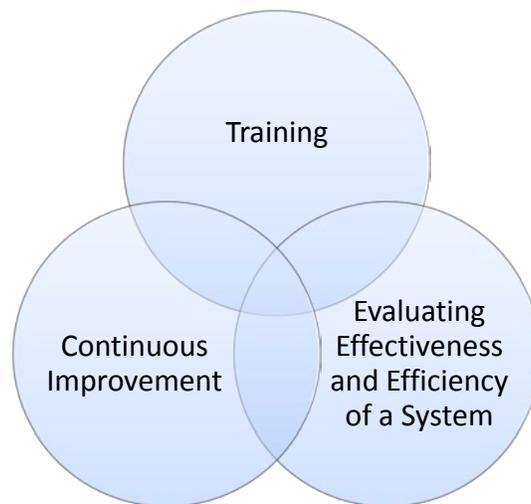


Figure 2-1 Venn Diagram of Research Areas

The two main online resources used to collect articles were Google Scholar and EBSCOhost. A variety of keywords were used to capture the scope of each research area, along with the overlapping research areas, as seen in Table 2-1. The research area of training encompasses multiple areas of training and specific aspects of management's role in training. The keywords used for CI covered all synonyms used in current literature. The keywords for the research area of "evaluating effectiveness and efficiency of a system" encompasses the effectiveness of CI implementation, the evaluation of the effectiveness and efficiency of more general systems (that is, safety devices, two-stage production process, video instruction, and so forth), and the evaluation of training systems. The following sections synthesize all pertinent research found for each research area.

Table 2-1 Keywords for Literature Review

Research Area	Keywords
Training	<ul style="list-style-type: none"> <li>• Employees – Training of</li> <li>• Occupational Training</li> <li>• Training</li> <li>• Training Benefits</li> <li>• Industrial Management</li> <li>• Management</li> <li>• Personnel Management</li> </ul>
Evaluating Effectiveness and Efficiency of a System	<ul style="list-style-type: none"> <li>• Cost Effectiveness</li> <li>• Effectiveness</li> <li>• Efficiency</li> <li>• Evaluating Effectiveness</li> <li>• Evaluating Effectiveness</li> <li>• Evaluation (of organizations)</li> <li>• Evaluation of Training</li> <li>• Manufacturing Processes</li> <li>• Training Evaluation</li> </ul>
Continuous Improvement	<ul style="list-style-type: none"> <li>• Continuous Improvement</li> <li>• Lean</li> <li>• Lean Implementation</li> <li>• Lean Manufacturing</li> <li>• Quality Control</li> <li>• Six Sigma (Quality control standard)</li> <li>• Total Quality Management (TQM)</li> </ul>

## 2.2 Training

Training includes many components including how training has evolved over time, why training is implemented throughout organizations, how training is developed, and how organizations evaluate the training. The following section covers the history, economy, devolvement, implementation, and methods of evaluating training.

### *2.2.1 Introduction to Training*

The basic idea of training revolves around individual learning. Training can lead to more satisfied employees and can potentially reduce turnover. Training is used in any competitive industry which chooses to keep up with changes in their industry (Farr & Sullivan Jr., 1996). According to Goldstein (1980), training is defined as “the acquisition of skills, concepts, or attitudes that results in improved performance in an on-the-job environment.” A formalized group formed in 1944 and is now the American Society for Training and Development (ASTD) (formally known as the American Society of Training Directors). The goal of the organization is “to raise the standards and prestige of the industrial training profession and to further the professional’s education and development.” (“History - ASTD,” n.d.).

The goal of training is often “one of preventing mistakes, errors, defects, and waste, not correcting them” (Nickols, 2000) as well as closing any gaps employees have in skills (Berge, 2008). The purposes of training includes teaching individuals (Berge, 2008) as well as, according to Nickols (2000) to focus energy on issues, promote change, create a community based on a shared experience, build teams, certify and license, and develop skills – to name a few. A benefit to training is that more workers can share the responsibilities in various circumstances (Slomp et al., 2005).

When focused on changing organizational architecture, training needs to assist in a slow change of behavior and new attitudes toward work, career, and colleagues (Dimancescu, Hines, & Rich, 1997). The importance of training in enhancing job performance is increasing due to the

increasing reliability on computers to conduct work (Muchinsky, 1997; Vorobyov, 2005). Training was best described in an ASTD article by Graber, Post, and Erwin (1997) as having “no inherent value; its worth is dependent on performance gains it catalyzes, the performance gaps it addresses, and the opportunities it can help create in a given environment.”

### *2.2.2 Economics of Training*

Training has historically played an important role in many modern organizations. A study from 1996 found that “New employee training takes place in 89% of U.S. organizations with 100 or more employees, while higher-level management training in leadership, performance appraisals, and interpersonal skills is conducted in 85% of these organizations” (Farr & Sullivan Jr., 1996, p. 30). Training can be viewed as an investment with a significant return, if implemented properly (Fayek, Yorke, & Cherlet, 2006). A 1995 study of United States industries with 100 or more employees shows that \$52 billion went towards training employees (Farr & Sullivan Jr., 1996). More recently (Aguinis & Kraiger, 2009, p. 452) stated that, “According to a recent industry report by the American Society for Training and Development (ASTD), U.S. organizations alone spend more than \$126 billion annually on employee training and development (Paradise, 2007)”. Training trust funds for Alberta Canada’s apprenticeship program for trades people is valued at around \$30 million (Fayek et al., 2006). The importance and need for measuring the return on investment for training is further highlighted by the estimate that training and human resource programs represent between 1.3% to 13% of an organization’s payroll (McCloskey, 2002; O’Connell, 1996; Poirot, 1987). U.S. industry is clearly investing a sizable amount of money in training. Like any investment, it is critical for organizations to manage this investment to ensure that the greatest gain possible results.

### *2.2.3 Training Development and Implementation*

Training is an important step in preparing to meet an individual's long-term career goals, enhance skills needed in the short term, fill gaps in performance or to keep up with change within the industry (Forsyth, 2006). The first step to training development is an assessment of training needs. A needs assessment should determine current training practices, desired program results, and a justification for training (Kuprenas et al., 2000).

This assessment can be split into a three-step process consisting of organizational, task, and personal analysis (Muchinsky, 1997). Organizational analysis focuses on determining when and where the training could be used. This analysis can also investigate how the training will transfer to job functions of individuals. The effectiveness of transferring skills from training to the job depends on management support (Baumgartel & Jeanpierre, 1972; Dolezalek, 2010; Muchinsky, 1997; Norcross, 2007; Wagner, 2009), transfer climate (Dolezalek, 2010; Kligyte et al., 2008; Kuprenas et al., 2000; Muchinsky, 1997), and maintenance of skills (Kuprenas et al., 2000; Muchinsky, 1997; Y. Wang, Goodrum, Haas, & Glover, 2008).

The task analysis involves four steps: develop task statements, develop task clusters, prepare knowledge, skill, and ability (KSA) analysis, and develop training programs from the task links. Task analysis is aimed at enhancing KSA's critical to job performance (Muchinsky, 1997).

The person analysis answers two questions: Who needs training, and what kind of training (Haque & James-Moore, 2004; Muchinsky, 1997). Person analysis is undertaken with the use of

a performance based appraisal system which diagnoses employees' strengths and weakness, and evaluates administrative decisions. Person analysis can focus on both current needs, as well as future KSA gaps (Muchinsky, 1997). Various difficulties may arise in deciding when and what training to implement particularly if a training department is not familiar with job may not know what conditions (Goldstein, 1980).

After training has been developed, methods and techniques to implement the training must be established. Training methods encompass on-site and off-site models. On-site methods include, but are not limited to; traditional training, on-the-job training, simulation training, and learning by doing (Farr & Sullivan Jr., 1996; Jorgensen & Kofoed, 2007; Miyamoto, 1991; Muchinsky, 1997; Y. Wang et al., 2008). Off-site training methods include, but are not limited to, lectures, audiovisual material, conferences, interactive video, programmed instruction, and other evolving technologies (Farr & Sullivan Jr., 1996; Muchinsky, 1997). These types of training technologies continue to be used today.

The on-site training method of traditional training can provide insulation from interruptions. Problems with traditional training is that it is expensive, there is a lot to learn in a small amount of time, technology changes at a fast rate, trainees can become intimidated in larger groups, and traditional training can be removed from the application of the tools in the work environment (Farr & Sullivan Jr., 1996). Traditional training logistics include scheduling and managing the availability of classrooms. With traditional training it may be difficult to personalize instruction to suit the particular needs of a trainee (Miyamoto, 1991). Basic safety was seen as the most

important formal training program, “followed by introduction to power tools, construction, math, basic employability skills, and introduction to hand tools” (Y. Wang et al., 2008, p. 798). On-the-job training can be beneficial but it must be accompanied by a learning plan, on-site mentoring, coaching of the trainee, frequent feedback, and deliberate rotation of trainees (Y. Wang et al., 2008). Another on-site training method, simulation, is utilized to “replicate the essential characteristics of the real world necessary to produce learning and transfer” (Muchinsky, 1997, p. 190). Simulation may encompass role playing which is geared towards training a group of people learning together. Lastly, the on-site method of “learning by doing” can provide trainees an opportunity to experiment with principles and adapt it to current issues in a work environment (Jorgensen & Kofoed, 2007).

Off-site training methods utilize technology to create and exploit individual learning opportunities using means that can be cheaper and more effective than traditional instruction-oriented teaching (Farr & Sullivan Jr., 1996). Using technology for training allows individuals to selectively satisfy their needs for knowledge at the appropriate time (Miyamoto, 1991). Computer-assisted instruction can provide individualized training, reduce the amount of time and travel needed for training, and provide a flexible schedule (Geith, Vignare, Bourquin, & Thiagarajan, 2010; Popa, Stegaroiu, Georgescu, & Popescu, 2010). Various off-site training technologies used according to an industry report conducted in 1995 (in order of most-to-least utilized) included; videotapes, lectures, one-on-one instructions, role plays, games/simulation, case studies, computer-based training, audiotapes, films, non-computerized self study, self

assessment techniques, interactive video, video teleconferencing, multimedia, CD-ROM, and computer conferencing (Farr & Sullivan Jr., 1996).

Training can be difficult when there is a lack of time, inadequate resources, underfunding, priority conflicts, lack of clarity of needs and goals, underperformance in training skills, or experience (Forsyth, 2006). A possible negative outcome of training is for the employee to leave feeling unprepared and frustrated. Trainees should perform new tasks in front of the trainer with no assistance to show competence (Wagner, 2009). Training may fail to equip employees with the proper skills if there is insufficient identification of required skills, lack of support on the shop floor, or motivation for staff to obtain and retain skills (Norcross, 2007). An evaluation of training must take place to ensure goals are met and difficulties are avoided.

#### *2.2.4 Evaluation of Training*

Once pre-training analysis and methods have been implemented, an evaluation of a specific training will allow designers and planners to learn what may or may not have worked well. The evaluation of training consists of understanding the various methods for evaluation as well as the specific aspects of the training being evaluated.

##### *2.2.4.1 Training Evaluation Models*

Models can focus on gathering quantitative and/or qualitative measures to evaluate various aspects of training. Tools used for the evaluation of training most commonly include surveys with numerical responses, evaluation forms, interviews, and gathering of performance data (Fayek et al., 2006; Palo & Padhi, 2003; Slomp et al., 2005).

Previous research has created various models and guidelines for evaluating training. Training can be examined by determining if predefined training objectives were satisfied. This evaluation requires three elements: a review of the initial assessment of training needs, identification of various types of training, and the development and calculation of training effectiveness measures (Kuprenas et al., 2000) as illustrated in Figure 2-2.

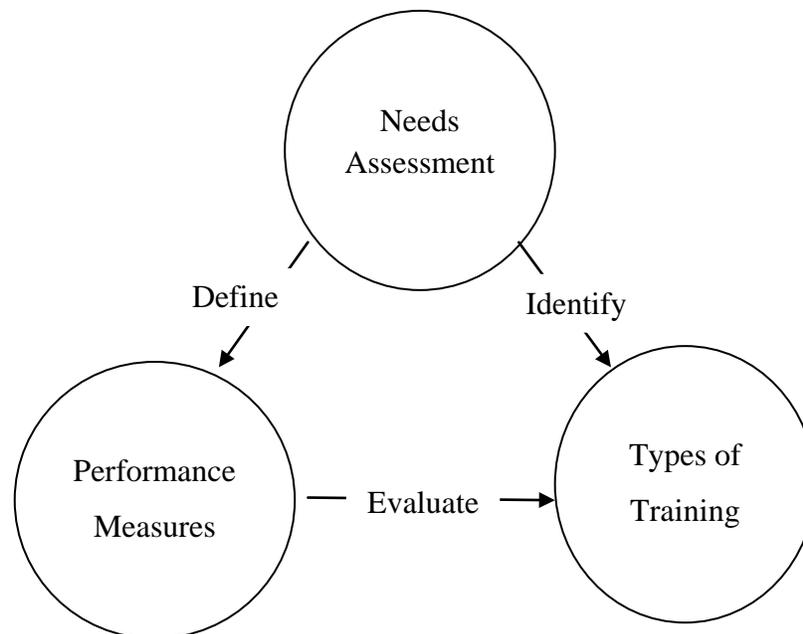


Figure 2-2. Training evaluation model. Adapted from “Performance Measurement of Training in Engineering Organizations.” by Kuprenas et al., 2000, *Journal of Management in Engineering*, 16, p. 28. Copyright 2000 by ASCE.

Kirkpatrick defined an evaluation model that consists of four levels (Parry, 1997). Each level targets a different issue and suggests different methods for evaluating the training. The Kirkpatrick model is summarized in Table 2-2.

Table 2-2 The Kirkpatrick model of the four levels for training evaluation.

Level	Issue	Evaluation Criteria	Method
1	Reaction	How well did trainees like the course?	Rating Sheets
2	Learning	How much did trainees learn?	Tests, Simulations
3	Behavior	How well did trainees apply knowledge, skills, behaviors?	Performance Measures
4	Results	What return did the training investment yield?	Cost-Benefit Analysis

Previous research has shown that the success of training events is dependent on the preparation and dedication of managers and more specifically on whether or not managers provide the necessary direction, leadership, and on-going support for the training (Dolezalek, 2010; Norcross, 2007; Tudor, 1994).

Training requires the efforts and commitment of three groups: managers, trainers, and trainees. Each group has a role to perform before, during, and after the training sessions. No training can be effective without input and response – throughout the process – from these groups (Tudor, 1994, p. 66).

Research conducted by Tudor (1994) demonstrated that separate evaluation criteria must be developed for each of the three groups. This model assumes a traditional training process, where only managers and trainers are assumed to be involved in the design of the training, and trainers and trainees are the only parties involved in the actual training event. This assumption is due to the fact that in many organizations, managers are trained separately from other employees. Table 2-3 summarizes the roles for each group before, during, and after training (Tudor, 1994).

Table 2-3 List of roles before, during, and after training (Tudor, 1994).

	Managers	Trainers	Trainees
Before Training	Define organizational strategy; set performance goals; provide support; communicate program and approved proposals.	Assess training needs to meet organization strategy; design training; assess employee characteristics and needs; submit training proposal to management.	Recognize need for training to support organization strategy; provide input about type of training needed; prepare for training.
During Training	Allocate resources; provide support; communicate status; take role of instructor if applicable.	Implement training program; assess training sessions; provide feedback to management; recommend changes as needed.	Apply knowledge and motivation to learning new skills and using new knowledge on the job.
After Training	Evaluate impact of training; communicate effectiveness of training; reward employee use of new knowledge and skills; develop longer-term training strategy and plans.	Help implement new training on the job; encourage employees to use new knowledge and skills; provide feedback to management; assess effectiveness of training; develop training programs and materials.	Apply new knowledge and skills to regular duties; assess and provide feedback to management on training effectiveness; provide input on future training.

The Tudor model shares similar evaluation criteria to the Kirkpatrick model, with the addition of evaluating managers, trainees, and trainers before the training event. In addition to Tudor's model, Koehorst & Verhoeven (1986) propose that the two most important factors in designing a training program are the choice of instructor and the training participants. The instructor must have a good understanding of the content area and of the employee's learning needs (Koehorst & Verhoeven, 1986). From a participant's perspective, participants within a training session should be at similar levels on the learning curve to minimize unnecessary training (Poulet, 1986).

Although these models have a high level of face validity, many organizations do not use a structured approach to designing training and/or to systematically evaluating and re-designing training. As a result, over time in some organization training materials and methods used, even if designed initially using a systematic process, may not be effective or appropriate to an organization after some time has passed.

#### *2.2.4.2 Approaches to Training Evaluation*

Based on the literature reviewed two main approaches to evaluating training were identified. These two approaches looked at evaluating the effectiveness of training as well as evaluating the efficiency of training. The following sections provide background information on approaches to evaluate training.

##### *2.2.4.2.1 Evaluating the Effectiveness of Training*

Previous researchers have worked on methods to evaluate the effectiveness of training. Evaluation of the success of training must take into account multiple outcomes (Phillips, 1998). Participant satisfaction, applicability of training, learning outcome achievement, on-the-job performance improvement, training impact, and return on investment are some examples of measures that can be used to evaluate the effectiveness of training. A common quantitative approaches used to measure the effectiveness of a training event is to determine the cost-effectiveness by translating a trained employee's productivity into monetary terms through utility analysis (Kumpikaitė, 2007). Some of these measures can help organizations not only understand the impact of the training, but can also be used to identify opportunities to improve the training. Overall, the measurement of the effectiveness of the training can provide

organizational leaders with an indicator of how wisely training dollars are being spent (Ostroff, 1991).

In order to effectively evaluate training, the evaluator must first question the intentions of the evaluation to know what the main focus is. If the evaluator is trying to observe the effectiveness of training, they should question the initial intentions of the training by asking: "...what is it [training] supposed to do? Change behavior? Shape attitudes? Improve job performance? Reduce defects? Increase sales? Enhance quality?" Nickols (2000, p. 2). Questioning why one evaluates training can help focus attention on specific aspects of the training. No matter the process and/or approach, the evaluation of training can be difficult since training

"...sometimes lacks planning, sponsorship, budget, or because training is done for the wrong reasons. Evaluation of training is also difficult because operating unit managers are looking for increased performance and not necessarily the increased learning on which trainers usually judge the success of their training. Additionally, in almost all cases, the lack of performance is only partially due to the need for training. Training's effectiveness in helping to increase performance is reduced even further since training is often wasted because the skills and knowledge gained in training are not applied on the job and thus have no impact. Add to these things, the antiquated accounting methods used to measure and evaluate training, and it becomes easy to understand why evaluation of the impact training has within the organization is difficult." (Berge, 2008, p. 390)

The findings discussed in the following sections are based on literature from both researchers and practitioners. As a result, some of the studies were empirically-based. Others were based on the experiences of practitioners or industrial consultants. A variety of case studies evaluating the effectiveness of training were reviewed. An empirical study conducted by Palo and Padhi (2003)

evaluated the effectiveness of training using surveys. The focus of the surveys was to measure the effectiveness of TQM (Total Quality Management) training. (Schmееckle, 2003) compared on-line training in a real-world context to classroom training. The impact of the two types of training was compared using a variety of approaches. The research team used learning outcomes, learner attitudes and motivation, and cost/benefit ratios to measure the success of the training. In another empirical study, the optimal amount of time for training was measured by calculating the time needed for an employee to learn a task while maintaining a positive correlation to actual performance (Montazemi & F. Wang, 1995). Another study examined the effects of instruction using information presented on employee performance. The effects were measured using learning outcome achievement (Dillon & Gabbard, 1998). The findings from the literature can be summarized based on the key components used to evaluate training effectiveness and include financial, trainees, trainers, management, and organization.

#### *2.2.4.2.1.1 Aspects Specific to Finances for Effective Training*

Return on investment is an important measure of the effectiveness of a training event (Fraser, 2008; Graber et al., 1997; MacDonald, Bullen, & Kozak, 2010; McCloskey, 2002). The return on investment can be measured by looking at costs and savings, which are calculated using labor rates, required time, skills and training commonalities, and staffing performance factors (MacDonald et al., 2010; Marentette et al., 2009). Various examples of the financial impact of training can be found in the literature, as outlined in Table 2-4. Some specific examples are savings resulting from a decreased number of claims as a result of improved levels of safety (Bell & Grushecky, 2006), a reduction in the amount of time (and subsequently reduced costs) associated with completing a particular job (Ostroff, 1991), decreased turnover rates (Hequet,

1993), and an increase in the contribution level of an employee due to increased skills and/or improved performance. MacDonald et al. (2010) and Palo & Padhi (2003) concluded that if training is to be successful, an organization must allocate money to support the training. Investments in resources utilized throughout the training event play a key role in employee retention of content (Norcross, 2007).

Table 2-4 Aspects Specific to Financial Evaluation for Effective Training

Aspects Specific to Financial Evaluation	(Phillips, 1998)	(MacDonald et al., 2010)	(Palo & Padhi, 2003)	(Bell & Grushecky, 2006)	(Ostroff, 1991)	(M. Hequet, 1993)
Reduction in time to complete a job	X				X	
Decrease in safety claims				X		
Decrease in turn-over rate	X					X
Increase in employee involvement	X	X				
Amount of money allocated to training	X	X	X			

#### 2.2.4.2.1.2 Aspects Specific to Trainee for Effective Training

The following section summarizes aspects specific to the role of a trainee used to measure the effectiveness of training. The aspects of the trainee focused on the impact of training on the trainee before, during, and after the training event.

Previous research has shown that prior to training, an analysis and plan must be created to identify and include a target population for the training (Dolezalek, 2010; Forsyth, 2006;

Jorgensen & Kofoed, 2007; Noe, 1986; Walter, 2009), as well as ensure the coursework is available to the proper employees (Kuprenas et al., 2000). This is because trainee characteristics play a key role in “the facilitation of both the acquisition and transfer of the metacognitive reasoning strategies” (Kligyte et al., 2008, p.273). Lastly, prior to training, activities and delivery techniques should be tailored to meet the individual differences among trainees (Kligyte et al., 2008).

The amount of involvement from the trainee (Walter, 2009), resources used (Parry, 1997; Walter, 2009), attendance, and comprehension of material (Kuprenas et al., 2000) should be observed during training.

A post training evaluation of the trainee is key to evaluating the effectiveness of a training program. This evaluation includes the utilization of what was learned (Kuprenas et al., 2000; Phillips, 1998), perceived effects on workers’ attitudes, safety, productivity, and quality of work (Fayek et al., 2006), participant satisfaction, learning outcome achievement, on-the-job performance improvement, and training impact (Phillips, 1998). The understanding of the training should be evaluated by looking at measurements of the instruction, measurements of the learning, and maintenance of learning (Kuprenas et al., 2000). The retention of trainees is dependent upon how the material is delivered. The material must be delivered, when it matters, through action and experience, with support from trainers/managers, with feedback (both bad and good), repeated over time, and with peer support (Norcross, 2007). Palo & Padhi (2003) found that training can create awareness, build employee commitment to quality policies and

strategy, facilitate teamwork, raise the standards for performance, and improve the overall skills and abilities of the employees. The results of the field study suggested that the training could be more effective if it focuses on improving employee communication competencies, multi-skill development in employees, and increased understanding of customer values by employees. Table 2-5 and Table 2-6 summarizes aspects specific to a trainee for effective training.

Table 2-5 Aspects Specific to Evaluation of Trainee for Effective Training

Aspects Specific to Evaluation of Trainee	(Noe, 1986)	(Palo & Padhi, 2003)	(Parry, 1997)	(Tudor, 1994)	(Walter, 2009)	(Dolezalek, 2010)	(Ostroff, 1991)	(Kuprenas et al., 2000)	(Forsyth, 2006)	(Jorgensen & Kofoed, 2007)	(Norcross, 2007)
Identification of target population	X				X	X		X	X	X	
Awareness of the importance of the training event	X	X		X	X						
Application to trainee's daily duties and responsibilities	X		X	X	X	X	X	X	X	X	X
Existence of performance goals			X	X							
Understanding of how training session fits into the long term goals of the organization		X	X	X							
Effectiveness of teaching aids			X								
Use of resources		X	X								X
Future applicability of the training session	X		X		X	X	X	X	X	X	
Support from managers for applying new tools in the workplace		X		X				X			X

Table 2-6 Aspects Specific to Evaluation of Trainee for Effective Training - continued

Aspects Specific to Evaluation of Trainee	(Noe, 1986)	(Palo & Padhi, 2003)	(Parry, 1997)	(Tudor, 1994)	(Walter, 2009)	(Ostroff, 1991)	(Kuprenas et al., 2000)	(Fayek et al., 2006)	(Kligyte et al., 2008)	(Phillips, 1998)
Knowledge of content area prior to training session					X					
Perceptions of training prior to training session			X							
Ability to provide feedback on performance of trainer			X							
Resources used in training session			X		X					X
Knowledge of the personal benefits of the training					X			X		
Ease of applying new tools, skills, knowledge in work environment	X		X			X	X	X		X
Level of involvement by trainees during training session					X					
Comfort level of trainees during training session			X							
Level of buy-in from trainees	X				X			X		X
Level of customization of the material to the audience				X					X	

#### 2.2.4.2.1.3 Aspects Specific to Trainer for Effective Training

The roles and responsibilities of a trainer overlap with those of a manager in organizations that do not have an established training department. This section will focus on the employee planning the training event, as well as delivering the training.

A trainer must work with management to help with pre-training analysis and planning for implementing an effective training strategy (Tudor, 1994), as is outlined in Table 2-7.

Table 2-7 Tudor (1994) “Action Steps for Implementing an Effective Training Strategy”.

1. Define and communicate the business or factor strategy.
2. Identify specific (people, team, organizational) skills required to implement the stated strategy.
3. Compare the current organizational skills to those identified as required to implement the strategy.
4. Review the assessment data with appropriate functional groups to gain consensus and support.
5. Set training priorities based on consensus reached.
6. Develop a three-year training and implementation plan, to be updated annually.
7. Review training and implementation plan for completeness, priorities, business focus and formal management.
8. Initiate training program and implementation plan.
9. Continuously communicate status of training, implementation plan, and results of continuous measurement of key plan indices.
10. Evaluate results on an on-going basis and modify overall plan as needed to meet the business strategy.

The primary role of a trainer occurs during the training event. The traditional role of a trainer is to assess training needs, design training, and deliver training, and measure training. Hequet (1995) suggests that additional tasks for the trainer are to work with executives to devise a strategy, maintain contact with employees to determine what skills are needed, train managers how to become trainers, help facilitate process improvement, and adapt to different learning styles. This means trainers must know how to listen, negotiate, coach, facilitate small-group interaction, problem solve, facilitate change, and know business processes (Hequet, 1995). The relationship between trainer and managers is further emphasized by Hequet (1995, p. 28) in that “one reason HR and training [departments] lose credibility is that top management looks over there and sees people who don’t have a clue, who don’t know what return on equity or attribution mean, or who can’t tell what’s the latest problem on the custom lines.” The trainer should be

able to protect the program and trainees from potential social, cognitive, psychological, and physical liabilities (Dolezalek, 2010). Additionally, the trainer activities and delivery techniques should be tailored to meet the individual differences among trainees (Kligyte et al., 2008).

The retention of trainees is dependent upon how the material is delivered. The material must be delivered, when it matters, through action and experience, with support from trainers/managers, with feedback (both bad and good), repeated over time, and with peer support (Norcross, 2007).

Table 2-8 summarizes aspects specific to a trainer for effective training.

Table 2-8 Aspects Specific to Evaluation of Trainer for Effective Training

Aspects Specific to Evaluation of Trainer	(Tudor, 1994)	(Walter, 2009)	(Dolezalek, 2010)	(Norcross, 2007)	(Hequet, 1995a)	(Kligyte et al., 2008)
Communication with managers on status of training	X					
Encourage participation from trainees		X		X		
Communication with trainees	X		X	X		
Create long-term training plan	X					X
Organize personnel	X				X	X
Evaluate training	X				X	
Deliver training	X	X	X	X	X	X

#### *2.2.4.2.1.4 Aspects Specific to Managers for Effective Training*

The roles and responsibilities of a manager overlap with those of a trainer in organizations that do not have an established training department. This section will focus on only the aspects related to the manager before and after the training event.

The typical roles of management within an organization are to accrue revenue, increase productivity, and reduce costs. Managers aim for increases in efficiency, effectiveness, productivity, creativity, and tangible results. The role of a manager in achieving these goals creates a responsibility to ensure individuals are being developed to help them do their job both currently and in the future (Forsyth, 2006).

Leadership and communication skills are important for managers (Goh, Coaker, & Thorpe, 2008). In addition to daily tasks, managers must work with trainers or at times become a trainer to help build the knowledge and skills of their employees. Managers must work with trainers to help create a training plan, and processes for evaluating the training (Dolezalek, 2010; Forsyth, 2006; Jorgensen & Kofoed, 2007; Noe, 1986; Walter, 2009). Managers must also enthusiastically support the training (Palo & Padhi, 2003).

As previously discussed, retention of trainees is dependent on support from trainers and managers, with feedback (both bad and good) (Norcross, 2007). Managers should communicate with employees on why they are in training, the expected changes, debrief materials taught, encourage employees to use new learned tools, and provide ways for trainees to hold each other

accountable to practice material taught (Dolezalek, 2010). Table 2-9 summarizes aspects specific to a manager for effective training.

Table 2-9 Aspects Specific to Managers Evaluation for Effective Training

Aspects Specific to Evaluation of Managers	(Noe, 1986)	(Palo & Padhi, 2003)	(Parry, 1997)	(Tudor, 1994)	(Walter, 2009)	(Dolezalek, 2010)	(Forsyth, 2006)	(Norcross, 2007)	(Goh et al., 2008)	(Jorgensen & Kofoed, 2007)
Plan training to meet employee needs							X			X
Encourage participation from trainees		X			X					
Communication with trainees		X		X		X		X	X	
Knowledge of material				X		X				
Knowledge of how this training fits into the overall goals and business strategy of the organization	X		X	X	X	X			X	
Observations of appropriate application of course material				X				X		
Observations of changes in employees' attitudes after training event	X		X				X	X		X
Amount of involvement in selecting trainees to be involved				X		X	X			X
Amount of involvement in creating/tailoring training material to trainees				X		X	X			
Understanding level of buy-in from trainees	X				X		X	X	X	X
Use of data to identify progress and contribution of training sessions on the organization				X		X				

#### *2.2.4.2.1.5 Aspects Specific to Organizations for Effective Training*

The aspect of the organization includes organizational goals, organization of employees and overall priorities. A main factor identified in the literature is processes which links training to the overall organizational strategy (Dolezalek, 2010; Forsyth, 2006; Jorgensen & Kofoed, 2007; Noe, 1986; Walter, 2009). An organization must understand the goals of a program before it can determine if the program was effective (Dolezalek, 2010). The content of the training coursework must be able to be utilized in the work place to meet the needs assessment objectives of the organization. Post training evaluation of effectiveness should look at availability of training course (Kuprenas et al., 2000). The effectiveness of employee training can be quantitatively evaluated by setting target objects throughout an organization and seeing how many objectives were met within a given time period (Fayek et al., 2006). The amount of resources and money allocated to training also play a role in determining the success of that training.

#### *2.2.4.2.2 Evaluating the Efficiency of Training*

The emphasis on increasing the efficiency of all areas of work includes the process of training (Muchinsky, 1997). Nickols (2000, p. 2) addresses the approach of evaluating the efficiency of training when he asked; “What about efficiency? How much time does the training consume? Can it be shortened? Can we make do with on-the-job training or can we completely eliminate training by substituting job aids instead?”

There has been very little research related to measuring training efficiency. Process efficiency for training is a measure of the resources committed to a training process relative to the desired output or objectives. A more efficient training process requires fewer resources e.g. materials,

time, and staff for a given set of training goals than a less efficient training process (Atkinson, 2004; Muchinsky, 1997; Ward, Parkin, & Medsker, 2006). If evaluation criteria are created to measure the efficiency of training, an organizational leader can determine if a redesigned training process can cover the same content in less time using fewer associated materials, without lowering the quality of training. There is a need to identify both measures and processes for organizations to use to evaluate training efficiency. Table 2-10 summarizes aspects specific to a trainee, trainer, and manager for efficient training.

Table 2-10 Aspects Specific to Trainee, Trainer, and Manager Evaluation for Efficient Training

	Aspects Specific to Trainee, Trainer, and Manager Evaluation	(Nickols, 2000)	(Palo & Padhi, 2003)	(Parry, 1997)	(Tudor, 1994)	(Walter, 2009)
Trainee	Amount of time during training that does not provide value to trainee	X				
Trainer	Time allocated for training	X		X		
	Ability of trainer to prioritize the most valuable content				X	
	Time wasted due to lack of preparation	X			X	
	Time wasted due to covering content already understood by trainees or is not applicable to their job	X				X
Manager	Ability to identify training priorities				X	
	Appropriateness of resource allocation		X			X

## 2.3 Continuous Improvement

The following sections introduce continuous improvement, provide a brief history, and explain characteristics of organizations implementing continuous improvement. It should be noted the labels of “continuous improvement” and lean are used interchangeably throughout these sections due to the fact that much of the literature prefers the term “lean.”

### 2.3.1 *Introduction to Continuous Improvement*

According to (Jackson & K. Jones, 1996), “mastering lean production is the only option for companies that hope to be players in the next millennium.” Goals of implementing lean include shorter lead-times, reduced cost, and higher quality (Letens, Farris, & van Aken, 2011). The term “continuous improvement” is just one of many names for the concept of applying problem solving data-driven activities using cross-functional teams, small groups, and individuals to discover, analyze, and eliminate waste in production processes (Jackson & K. Jones, 1996). Synonymous keywords for CI, as outlined in Table 2-1, include lean, quality control, six sigma (quality control standard), and total quality management.

Continuous improvement is defined by Scott, Wilcock, & Kanetkar (2009, p. 209) as

a systemic approach to the measurement, analysis, and improvement of business processes to identify critical areas that can produce breakthrough results in market penetration, product quality attributes, quality assurance and/or manufacturing processes, customer satisfaction, cycle time and/or the cost of doing business.

Similarly, lean is defined as “continuous improvement, deploying cross-functional teams, small groups, and individual employees to discover, analyze, and eliminate waste in production processes.” (Jackson & K. Jones, 1996, p. 5).

Lean manufacturing differs from mass manufacturing principles in the areas of; customer satisfaction, leadership, organization, external relations, information management, culture, production, maintenance, and engineering (Jackson & K. Jones, 1996). A comparison of mass manufacturing versus lean manufacturing is provided in Table 2-11.

Table 2-11 A Comparison of Mass versus Lean Production. Adapted from “Implementing a Lean Management System” by Jackson & K. Jones, 1996, p.6. Copyright 1996 by Productivity Press.

	<b>Mass Manufacturing</b>	<b>Lean Manufacturing</b>
<b>Customer Satisfaction</b>	Make what engineers want in large quantities at statistically acceptable quality levels; dispose of unused inventory at fire-sale prices	Make what customers want with zero defects, when they want it, and only in the quantities they order.
<b>Leadership</b>	Leadership by executive fiat and coercion.	Leadership by vision and broad participation.
<b>Organization</b>	Individualism and military-style bureaucracy.	Team-based operation and flat hierarchies.
<b>External Relations</b>	Based on price.	Based on long-term relations.
<b>Information Management</b>	Information-poor management based on abstract reports generated by and for managers.	Information-rich management based on visual control systems maintained by all employees.
<b>Culture</b>	Culture of loyalty and obedience; subculture of alienation and labor strife.	Harmonious culture of involvement based on long-term development of human resources.
<b>Production</b>	Large-scale machines, functional layout, minimal skills, long production runs, massive inventories.	Human-scale machines, cell-type layout, multiskilling, one-piece flow, zero inventories.
<b>Maintenance</b>	Maintenance by maintenance specialists.	Equipment management by production, maintenance and engineering.
<b>Engineering</b>	Model of the isolated genius, with little input from customers and little respect for production realities.	Team-based model, with high input from customers and concurrent development of product and production process design.

The benefits of implementing lean concepts include reduced manufacturing and product lead time, higher labor efficiency and quality, greater market flexibility, longer machine life, and lower inventories (Jackson & Jones, 1996).

The traditional model used by managers to calculate profit is shown in Equation 1.

$$\Pi = Q \cdot (P - C) \quad (1)$$

Where

$\Pi$  = profit

$Q$  = quantity sold

$P$  = price per unit sold

$C$  = cost per unit

Organizations focused their efforts around mass producing to increase profit. This is because the theory of economics of scale allows organization to lower costs as they increase production quantities. This focus also created the belief that higher quality meant higher prices. Lean production focuses on lowering the cost per unit, mainly indirect costs, while maintaining quality. A lean facility can “make twice as much product of twice the quality in half the time and space, at half the cost – with a fraction of normal work-in-process inventory” (Jackson & K. Jones, 1996, p. 5). Lean thinking focuses on price and cost as a function of quality and speed. See Equation 2.

$$\Pi = Q \cdot (P[q, s] - C[q, s]) \quad (2)$$

Where

$\Pi$  = profit

$Q$  = quantity sold

$P$  = price per unit sold

$C$  = cost per unit

$q$  = quality

$s$  = speed

$P[q, s]$  = price as a function quality and speed

$C[q, s]$  = cost as a function quality and speed

Continuous improvement can be implemented using a wide variety of tools and concepts. These tools and concepts include, but are not limited to 5S, Kaizen, Just-in-Time, elimination of the seven deadly wastes, value stream mapping, Plan–Do–Check–Act (PDCA) cycle, cause and effect diagrams, fishbone analyses, and brainstorming (Álvarez et al., 2009; Bagadia, 2008; Jorgensen & Kofoed, 2007; Liker & J. M. Morgan, 2006; Scott et al., 2009; Womack et al., 2007).

In addition to identifying appropriate tools and concepts, a plan for training must also be developed. This plan will help ensure that leaders, managers, and line employees all have a clear understanding of how the chosen tools support the organization's improvement efforts (Jackson & K. Jones, 1996; Southworth, 2008). By developing a training plan before training sessions are deployed, organizational leaders can incorporate the need for training into the training materials (Muchinsky, 1997). How the training fits into the organizational strategy and the resources and communication strategies that will be used to support employees in using the tools and concepts

are also important elements in a training plan and should be shared as part of the training processes (Muchinsky, 1997; Tudor, 1994).

Once a plan and the CI tools and concepts are chosen, the content must be introduced to organizational members who will be using the tools and concepts for improvement. This introduction can be achieved through passive means, e.g., informing impacted employees through a memo or through more active means, e.g., holding a training event. The training event may be structured using traditional methods or possibly using active learning methods. Traditional training sessions typically occur in classroom settings and focus on teaching employees specific skills using lectures, videos, and/or PowerPoint presentations. The material used during traditional training sessions is often preset, i.e., not adapted for specific types of employees or specific work areas (Farr & Sullivan Jr., 1996; Miyamoto, 1991). CI training is unique in that it is highly kinesthetic and best understood by going out and executing a task to fully understand the concepts (Southworth, 2008).

In addition to providing employees with skills related to applying CI tools and concepts, another factor to consider in the development of training is that the initial training may also play a role in establishing employee attitudes towards the tools and concepts being introduced as well as towards the overall continuous improvement program. As a result, effective training may also have a strong effect on whether or not a CI program within the organization is successful. As a result, one goal of CI training is to tailor the training to be effective in the existing organizational

culture and to help move the organization forward towards improved levels of performance (Clark & Kwinn, 2005).

### *2.3.2 Implementation of Continuous Improvement*

The following section reviews the history of lean as well as characteristics of organizations undergoing a lean implementation. The literature around lean implementation focuses on factors that contribute to a successful implementation, as well as characteristics to look out for.

#### *2.3.2.1 History*

The concepts of lean production were pioneered after World War II by Eiji Toyoda and Taiichi Ohno at the Toyota Motor Company in Japan. At the time, the main manufacturing trend focused on mass manufacturing concepts introduced by Henry Ford and General Motors' Alred Sloan (Womack et al., 2007). The change in production principles came after the Japanese automotive industry was faced with limited resources and a highly competitive market. These changes introduced "a set of tools and practices that managers and workers could use to eliminate waste and inefficiency from production systems--reducing costs, improving quality and reliability, and speeding up cycle times" (Liker & J. M. Morgan, 2006, p. 6). In 1953, Japanese companies manufactured 50,000 cars. By 1960, Japanese companies increased their manufacturing to 500,000 cars (Berggren, 1994). By the 1970's Japanese companies manufactured 5 million cars (Berggren, 1994). Toyota started to become a model for competitive manufacturing and excelled in product development, teamwork, communication, and simultaneous development

(Dimancescu et al., 1997; Liker & J. M. Morgan, 2006; Womack et al., 2007). The principles developed at Toyota became known as the Toyota Production System (TPS).

Today, most manufacturing companies from around the world have adopted some form of a “lean initiative” to remain competitive. Various forms of lean concepts have been molded to meet the needs of many diverse operations including insurance companies, hospitals, government agencies, airline maintenance organizations, high-tech product-development, oil production facilities, IT operations, retail buying, publishing companies, supply chain networks and laboratories (Gras & Philippe, 2007; Liker & J. M. Morgan, 2006, p. 6).

#### *2.3.2.2 Characteristics of Lean Implementation*

Organizations tend to commit to the implementation of lean concepts in response to growing pressures from the business world. These pressures may result in goals aimed toward cost reduction, improved relations with their customer base or a particular customer, resolution of quality of product or delivery problems, meeting requirements, reducing cycle times, or launching and delivering new products or services (Atkinson, 2004). CI incorporates short term projects with a long term goal of sustaining a lean culture (Wagner, 2009).

Implementing lean principles throughout an organization requires a complex plan that works with the unique characteristics of the organization. These characteristics include but are not limited to the number of employees, existing quality structure, management setup, number of years as an established organization, and current culture. The successful implementation of lean

concepts requires commitment, training, and changes in behavior at all levels of management (Pyzdek, 2003). Managers must challenge their employees to try to find a way to make their processes better, faster, and cheaper, as well as help their employees understand that these changes will help make their jobs easier. Managers must show their commitment to this change and remain consistent in their actions. Managers should listen to employees and document successes to help reinforce the CI mind-set. Impacts of CI implementation should be measured and promoted throughout the organization (Harrison et al., 1997). Additionally, lean processes have to work harmoniously throughout the organization or else it may hurt the core quality standards (Strouse, 2008).

Once a plan has been developed, employees must go through training to learn and adapt these new principles. In the true nature of lean, the approach to continuous improvement training should be a “pull” process, where skill development is demanded from the workplace. Additionally, there needs to be assurance that skills are absorbed, retained, and utilized. Feedback should be given for both successes and failures. The six techniques to create a pull for new skills within an organization is to create pull by setting improvement objectives, visibly rewarding success utilizing; management recognition creating, peer-to-peer communication, building structured career progression, and building commitment (Norcross, 2007). The methods used for lean training may need to be altered due to the fact that many employees do not absorb the essential skills necessary in a lean environment in a classroom setting (Norcross, 2007). After training, front line personnel are expected to participate in activities that involve “problem

solving, identifying opportunities for process improvement and relentlessly eliminating waste” (Norcross, 2007).

CI is typically implemented using a bottom-up strategy to emphasize involvement and participation from front-line personnel (Jorgensen & Kofoed, 2007). Successful implementations of lean depend on how well the idea is “sold” to potential users (Atkinson, 2004). The three cornerstones to implementing lean include creating a strategy, ensuring structure, and utilizing strengths within the organization, as shown in Figure 2-3 (Jackson & K. Jones, 1996).

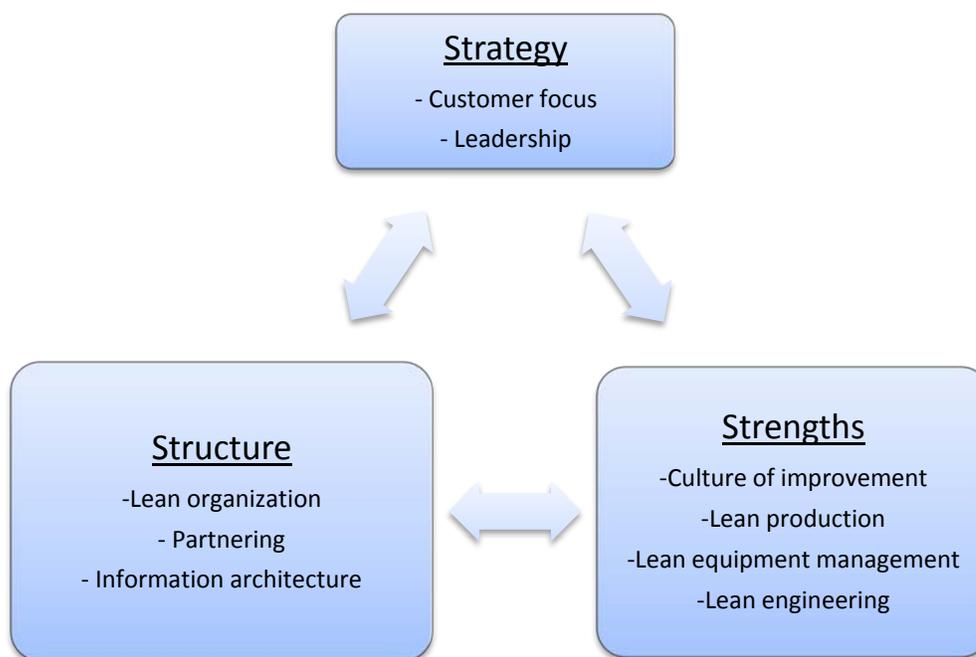


Figure 2-3 Three cornerstones of growth with keys to development. Adapted from “Implementing a Lean Management System” by Jackson & K. Jones, 1996, p. 20. Copyright 1996 by Productivity Press.

Proper implementation of lean includes an assessment as to how principles being introduced can be integrated into organization metrics (Osagie, 2009). Atkinson (2004, p. 21) provides an

example of such metrics; “reduction in failure rates, increase in delivery and customer service, reliability of deliverables, new business transacted, resources deployed to best advantage, ROI, increase in value added business transactions, relative increase in positive business activity, lost customers revived, prospecting rate, etc”.

There are many challenges to overcome both in the initial implementation, as well as sustaining, a lean program. One of the challenges when implementing lean concepts is for organizations that have dispersed locations spread throughout areas with drastically different cultures. This presents a challenge since the approach to lean implementation must be tailored to the specific group norms of a given environments (Liker & J. M. Morgan, 2006). Another challenge when implementing lean concepts is to remain consistent with lean tools used and to continually adapt the lean tools to fit the needs of the organization (P. Baker, 2003; Osagie, 2009). These tools have to extend beyond the shop floor into the board room, sales offices, and product development process (Atkinson, 2010; Liker & J. M. Morgan, 2006). The standard phases when introducing lean tools are to focus on defining customer values, mapping the value stream, improving flow, introducing a pull system, then improving the system. Lean is a good starting point for most companies in order to assess current performance and define future opportunities to increase competitiveness. More sophisticated tools such as Six Sigma and Total Productive Management should be left to more advanced stages of a lean implementation cycle (Baker, 2003).

Once a lean program has been successfully initiated, an organization can look forward to more standardized procedures, increased profits and decreased time between product development and

production (Baker, 2003; Liker & J. M. Morgan, 2006). Lean can saturate every aspect of an organization and help unite employees in a relentless drive for improvement. A balance must be found to ensure the tools are being used properly (Atkinson, 2004). Management must be careful to not get caught in the trap of requiring endless certifications as the means to lean implementation. Rather, certifications should enhance the implementation and sustainability of the lean tools being adopted (Carleysmith, Dufton, & Altria, 2009). Management should ensure that the people who work in the process are included and keep their attention on the human side of the enterprise (Atkinson, 2004). There should be consistent training and multiple channels of communication, as well as a process in which lean implementation is phased in building on successes of commendable examples (Carleysmith et al., 2009).

### *2.3.3 Evaluating Continuous Improvement Training*

Training is the base to quality and process improvement (Wagner, 2009). It is essential to weigh the advantages and disadvantages of training. This is necessary for any organization to ensure alignment not only with all operational processes, but equally important, the entire enterprise. Most empirical lean studies focus on lean once the tools have been taught (Matson & Stauffer, 2009).

The success of CI efforts depends on managements' ability to objectively evaluate the impact of any changes made (Harrison et al., 1997). CI training should be evaluated and, if possible, modified to better meet initial goals (Jorgensen & Kofoed, 2007). Evaluation of CI training can be more challenging than evaluating other more traditional training such as job skills training. The skills needed to succeed in implementing continuous improvement are often dependent on

both technical as well as interpersonal skills. For example, the successful application of continuous improvement tools, such as 5S, Kaizen events, creating standard work procedures, requires employees to work in teams and to communicate with both peers and organizational leaders. In addition, most continuous improvement activities require the active involvement of multiple stakeholders. For example, in a root cause analysis, successful deployment often requires that employees get buy-in from other stakeholders, particularly when implementing changes in work processes to address the identified root cause. This type of activity requires the employee to navigate a variety of interactions with peers as well as supervisors and potentially with other organizational leaders at various levels. As a result, to be successful, employees need to have both technical knowledge of the tools and concepts, as well as be able to effectively communicate findings to different stakeholders.

Second, CI is ultimately achieved through an iterative process. Employees do not typically master all the tools associated with continuous improvement through the completion of a single CI project that may be initiated as part of a single or a set of training sessions. As a result, training related to CI tools and concepts must enable employees to make the connection between the tools and concepts and if possible, future application of these tools and concepts (Baker, 2005).

An ideal CI training session would be structured to allow participants to practice the application of the tools and concepts and to experience the impact of the tools and concepts by seeing improvement resulting from the changes implemented. For this to occur, however, there must be

buy-in not only from the participant in the value of the training, as well as from other employees in a work area that might be impacted by changes made after the application of the CI tools and concepts. This can be challenging because CI activities often require changes to employees' job functions, and furthermore may be perceived by employees as undesirable or potentially as threatening to job security (Kirkland, 2001). These types of challenges must be anticipated and considered in the design of CI training.

### **3 Research Methodology**

This section summarizes the methodology used to develop and examine an evaluation measure specific to continuous improvement (CI) training. This description includes a summary of the construction, administration, collection, and analysis of multiple surveys. The case study site used for this research was a manufacturing organization. The manufacturing organization was located in the United States and focused on steel manufacturing. The organization consisted of less than 500 employees and has been in operations for over 40 years. The organization was involved in the early stages of CI training for front-line personnel, supervisors and managers. In the design of the CI training, the research team, in conjunction with organizational leaders, was charged with creating training materials and processes that would quickly enable these individuals to apply the tools and concepts of CI to problems that impacted product quality and manufacturing process efficiency. Based on early discussions of what was needed by the organization, a number of questions were raised about how to best design the training to meet the organization's needs.

#### **3.1 Survey Construction**

The survey construction was completed in three stages: literature survey, field study, and selection of dependent and independent variables. The findings from the literature survey were summarized in Section 2.2. The dependent and independent variables were then used to create the surveys. The following sections summarize each of these steps in detail.

### 3.2 Onsite Interviews

Following the framework development, a field study was conducted at the case study site. Semi-structured interviews of 18 organizational employees were conducted over a three month period. All interviews with employees were coordinated in advance with the designated primary contact at the plant. Interviews were scheduled so that they did not interfere with the participant's work responsibilities and/or required breaks. Participants were selected to get the input from employees representing all levels of the manufacturing organization.

The employees included in the field study worked in various functional areas and included individuals in management as well as front-line personnel. The interview protocol for management included 21 questions, which focused on their previous training experiences, as can be seen in Appendix A. The interview protocol for front-line personnel included 13 questions, which focused on their previous training experiences, as can be seen in Appendix B. In particular, the interview questions for both management and front-line personnel focused on understanding previous efforts to implement problem solving tools and techniques and/or process improvement training in the organization as well as other positive and negative training sessions experienced by the employees within the organization. To encourage candor during the interviews, the interviews were not recorded. However, the research team took detailed, hand-written notes throughout the interviews. The notes were later transcribed into an electronic format, and the electronic version of the notes was coded for this analysis. The research team was comprised of a graduate student and the graduate student's advisor. Permission to complete the interviews was granted by the Institutional Review Board (IRB). Both researchers completed

the “Certification of Education for the Ethical Use of Human Participants in Research Projects”, as required by the Oregon State University IRB.

### 3.2.1 Coded Data from Field Study

The evaluation aspects identified as a result of the literature review and field study were compared and contrasted. A coding system was developed based on the evaluation aspects identified in the literature review. Additional evaluation aspects emerged as a result of the coding process. Table 3-1, Table 3-2, and Table 3-3 outline the evaluation aspects established from the interviews conducted for employees involved in the training. Those evaluation aspects listed in bold text were identified in both the literature search and the field study. The number in parentheses listed next to each evaluation aspect indicates the number of interviewees who identified a particular evaluation aspect. A total 18 of interviewees were interviewed. Of the 18 interviewees, 8 were managers and 10 were front-line employees.

Table 3-1. Specific evaluation aspects for trainees identified from interviews. (Bold indicates evaluation aspect identified in both the literature search and the field study.)

Satisfaction with the training session schedule (10)
<b>Application to trainee’s daily duties and responsibilities</b> (14)
Comfort level of trainees in communicating with supervisor about training session (13)
<b>Knowledge of content area prior to training session</b> (5)
Level of engagement (10)
Whether or not training was voluntary or mandatory (3)
Appropriateness of teaching aids (10)
<b>Effectiveness of teaching aids</b> (8)
Ease of working with other group members during the training session (9)
Quality of relationship between trainer and trainee (6)
Appropriateness of training facility (6)
<b>Level of buy-in from trainees</b> (13)
<b>Amount of time during training that does not provide value to trainee</b> (10)

Table 3-2. Aspects specific to trainer evaluation identified from interviews.

Quality of relationship between trainer and trainee (10)
Level of trainee involvement (7)
Level of trainer's knowledge of content area (9)
Time allocated for training (8)
Scheduling of training relative to other work area priorities (6)

Table 3-3. Aspects specific to manager evaluation identified from interviews. (Bold indicates evaluation aspects identified in both the literature search and the field study.)

Appropriateness of training session schedule (7)
<b>Level of buy-in from trainees (13)</b>
<b>Managers knowledge of material (8)</b>
Manager to worker ratio (2)

The same evaluation aspects were, in many cases, identified in more than one interview. Table 3-4. summarizes the ten evaluation aspects that were cited the most often by different individuals during the interviews.

Table 3-4. The ten most-cited evaluation aspects. (Bold indicates aspects identified in both the literature search and the field study.)

<b>Application to trainee's daily duties and responsibilities</b>
Comfort level of trainees in communicating with supervisor about training session
<b>Level of buy-in from trainees</b>
Level of engagement
Appropriateness of teaching aids
Quality of relationship between trainer and trainee
<b>Amount of time during training that does not provide value to trainee</b>
Level of trainer's knowledge of content area
Ease of working with other group members during the training session
Satisfaction with the training session schedule

### *3.2.2 Synthesized Findings from Field Study*

Ten different participants mentioned the importance of the training schedule. In particular, the front-line employees noted that often times training was scheduled during day shift and/or during week-days. Since not all front-line employees work day shift or on weekdays, training sessions that were scheduled in off-times or on off-days were not viewed positively. In addition, the location of the training session was also viewed as a potential source of frustration. A specific example of this was a training session that was held at a distant location from the plant. In addition to the location, the room that was used had poor circulation and was not large enough to accommodate the entire group of trainees. This created unnecessary stress, attributed to the discomfort resulting from the hot room and the lack of personal space, making it difficult for trainees to concentrate on the materials.

The opinions of the front-line personnel who participated in the interviews indicated that one of the main evaluation aspects used by these employees to evaluate a training session was the employee's perception of the applicability of the training session to their daily responsibilities. If trainees did not understand the benefit of a particular training session, the level of trainee participation was decreased and perceptions of the value of any proposed, future training was also negatively impacted.

The relationship between the front-line employees and executives in the organization also came up as a discussion point in many of the interviews conducted. In particular, the need for clear communications between front-line employees and supervisors and managers in the organization

was identified as being important to the success of any planned training sessions. Secondly, support from executives was perceived by front-line employees as being a key element in establishing trust and was evidenced to front-line employees when managers were able to provide guidance on how employees could apply the training content. The level of knowledge of executives on the tools and concepts covered during the training was seen to be an important enabler in the training process. A common base of knowledge and the ability to use and understand the same terminology were both important factors. Lastly, it was noted during the interviews that individuals with established leadership roles in the organization were more effective trainers, in part because these individuals had already established a trusting relationship with trainees.

The front-line employees that were interviewed also noted that while most did enjoy participating in training sessions, sessions that were voluntary were perceived as being more effective than those that were mandatory. Most specifically, the idea that the employee could not continue working if they did not complete the training was seen as unreasonable, and the mandatory training sessions were viewed more negatively by the front-line employees.

The evaluation aspects identified as a result of both the literature review and field study were then synthesized to create a preliminary model of training effectiveness and efficiency. The data synthesized from the interviews was used to construct the survey items used in the empirical analysis.

### 3.3 Variables

Variables were synthesized from the literature review and field study. Independent and dependent variables to be analyzed were then identified.

#### *3.3.1 Synthesis of Variables*

A synthesis of variables from the literature review and field study is summarized in Table 3-5, Table 3-6, and Table 3-7. Evaluation aspects identified was explained using six categories; time, resources, communication, planning, effectiveness, and efficiency.

Table 3-5 Synthesis of Variables from Field Study

Evaluation Aspects	Evaluation Categories					
	Time	Resources	Communication	Planning	Effectiveness	Efficiency
Trainee's satisfaction with the training session schedule (10)	X				X	
<b>Application to trainee's daily duties and responsibilities</b> (14)		X			X	
Comfort level of trainees in communicating with supervisor about training session (13)			X		X	
<b>Knowledge of trainees content area prior to training session</b> (5)						X
Trainees' level of engagement (10)			X		X	
Whether or not training was voluntary or mandatory (3)				X	X	
Appropriateness of teaching aids (10)		X		X	X	
<b>Effectiveness of teaching aids</b> (8)		X			X	
Ease of working with other group members during the training session (9)				X	X	
Quality of relationship between trainer and trainee (6)			X		X	
Appropriateness of training facility (6)				X	X	
<b>Level of buy-in from trainees</b> (13)			X		X	
<b>Amount of time during training that does not provide value to trainee</b> (10)	X					X
Quality of relationship between trainer and trainee (10)			X		X	
Level of trainee involvement (7)					X	
Level of trainer's knowledge of content area (9)		X				X
Time allocated for training (8)	X					X
Scheduling of training relative to other work area priorities (6)				X		X
Appropriateness of training session schedule (7)	X					X
<b>Level of buy-in from trainees</b> (13)			X		X	
<b>Manager's knowledge of material</b> (8)		X			X	
Manager to worker ratio (2)				X		X

Table 3-6 Synthesis of Variables from Literature Review

Evaluation Aspects	Evaluation Categories					
	Time	Resources	Communication	Planning	Effectiveness	Efficiency
Reduction in time to complete a job						X
Decrease in safety claims						X
Decrease in turn-over rate					X	
Increase in employee involvement					X	
Amount of money allocated to training						X
Managers identification of target population		X		X	X	
Managers awareness of the importance of the training event				X		
Application to trainee's daily duties and responsibilities				X	X	
Existence of performance goals				X	X	
Managers' understanding of how training session fits into the long term goals of the organization			X	X	X	
Effectiveness of teaching aids		X			X	
Use of resources		X			X	
Future applicability of the training session	X				X	
Support from managers for applying new tools in the workplace			X		X	
Trainees' knowledge of content area prior to training session			X	X		X
Trainees' perceptions of training prior to training session			X	X	X	
Trainees' ability to provide feedback on performance of trainer			X			
Resources used in training session		X			X	
Trainees' knowledge of the personal benefits of the training			X		X	
Trainees' ease of applying new tools, skills, knowledge in work environment		X			X	
Level of involvement by trainees during training session		X		X	X	
Trainees' comfort level of trainees during training session			X	X	X	

Table 3-7 Synthesis of Variables from Literature Review - continued

Evaluation Aspects	Evaluation Categories					
	Time	Resources	Communication	Planning	Effectiveness	Efficiency
Level of buy-in from trainees			X	X	X	
Level of customization of the material to the audience		X		X		X
Trainers communication with managers on status of training			X			X
Trainers encourage participation from trainees			X		X	
Trainers communication with trainees			X		X	
Trainers create long-term training plan				X	X	
Trainers organizes personnel			X	X	X	
Trainer evaluates training		X			X	
Trainer delivers training		X			X	
Amount of time during training that does not provide value to trainee	X					X
Time allocated for training	X					X
Ability of trainer to prioritize the most valuable content		X		X		X
Time wasted due to lack of preparation		X		X		X
Time wasted due to covering content already understood by trainees or is not applicable to their job		X		X		X
Ability to identify training priorities		X				X
Appropriateness of resource allocation		X				X

The evaluation aspects identified from interviews and literature relate to one or more categories. Most evaluation aspects relate to two or more categories. The first identified category was to time, resources, or communication. The second category was effectiveness or efficiency. Evaluation aspects related to planning usually had a third relation to time, resources, or communication. The category of planning was eliminated from variables identified to evaluate

training due to the observed dependence between planning and the categories of time, resources, and communication.

### 3.3.2 *Independent Variables*

The independent variables defined focused on aspects of the training which change for each training session. These variables were determined after a review of the results found from an onsite interview and the survey of previous research from the literature. Each of the independent variables identified are operationalized in Table 3-8.

Table 3-8. Definition of Independent Variables

<b>Variable</b>	<b>Definition</b>
Time	Time used during the training session. Specific aspects of time will be captured, such as time spent on each activity.
Resources	Resources include the trainer, training material, tools used to assist throughout the session, and any additional material used.
Communication	Communication is focused on the communication held before and during the training session. The various types of communications being evaluated are between trainers, trainees and managers.

The time variable focused on the time allotted for training and aspects related to how the time was spent, including satisfaction with the training session schedule, the amount of preparation to limit wasted time, and covering material applicable to trainees.

The resources variable focused on training aids used during and after training. The various aspects studied were the level of customization of teaching aids, the appropriateness of teaching aids and training facility, and the level of training aids used during and after a training session.

The communication variable observed focused on various aspects of communication between management, trainers, and trainees. The various aspects of communication studied were the comfort level of trainees in communicating with supervisors about the training session and the status of training and the amount of encouragement for participation.

### 3.3.3 *Dependent Variables*

The dependent variables were identified after a review of previous research. Each dependent variable is operationalized in Table 3-9 and discussed.

Table 3-9. Definition of Dependent Variables

<b>Variable</b>	<b>Definition</b>
Effectiveness	The effectiveness is the impact of the training on the trainee and their environment. More specifically, the effectiveness of the training was focused on the usefulness of training content to the employees' work area.
Efficiency	Efficiency is using the least amount of energy to complete a particular task (focuses on quantity of time, resources, and communication)

The effectiveness variable focused on various aspects of the impact the training had on the trainees and their workplace. The aspects of effectiveness studied included awareness of the importance of the training, measurement of impact compared to performance goals, level of buy-in, and the progress of training sessions.

The efficiency variable focused on various logistics. These aspects included the amount of preparation of teaching aids, communication prior to the training, time spent repeating information, prioritization of training events, and resource allocation.

### 3.4 Hypothesis Construction

Hypotheses were constructed to address the research objective as outlined in Table 1-1. H1 and H2 focus on the direct link between time, resources, and communication and effectiveness and efficiency as shown in Figure 3-1 and outlined in Table 3-10.

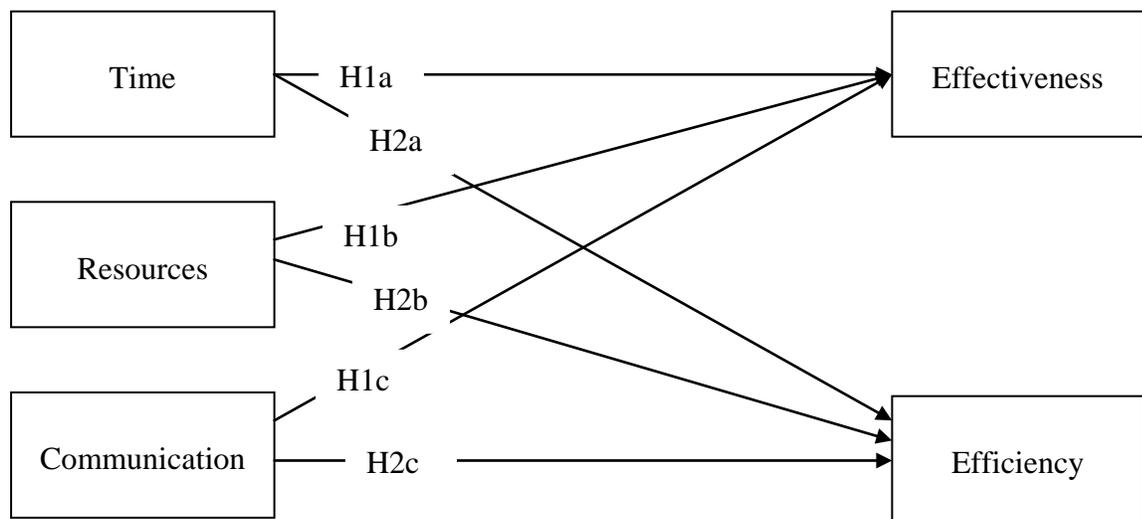


Figure 3-1 Research Hypotheses H1 and H2

Table 3-10 Research Hypotheses List for H1 and H2

	Hypotheses
<b>H1a</b>	Time (T) has a direct relationship with effectiveness
<b>H1b</b>	Resources (R) has a direct relationship with effectiveness
<b>H1c</b>	Communication (C) has a direct relationship with effectiveness
<b>H2a</b>	Time (T) has a direct relationship with efficiency
<b>H2b</b>	Resources (R) has a direct relationship with efficiency
<b>H2c</b>	Communication (C) has a direct relationship with efficiency

Research hypotheses H3 focused on the impact time, resources, and communication had in combination on effectiveness and efficiency. The hypothesis statements are outline in Table 3-11.

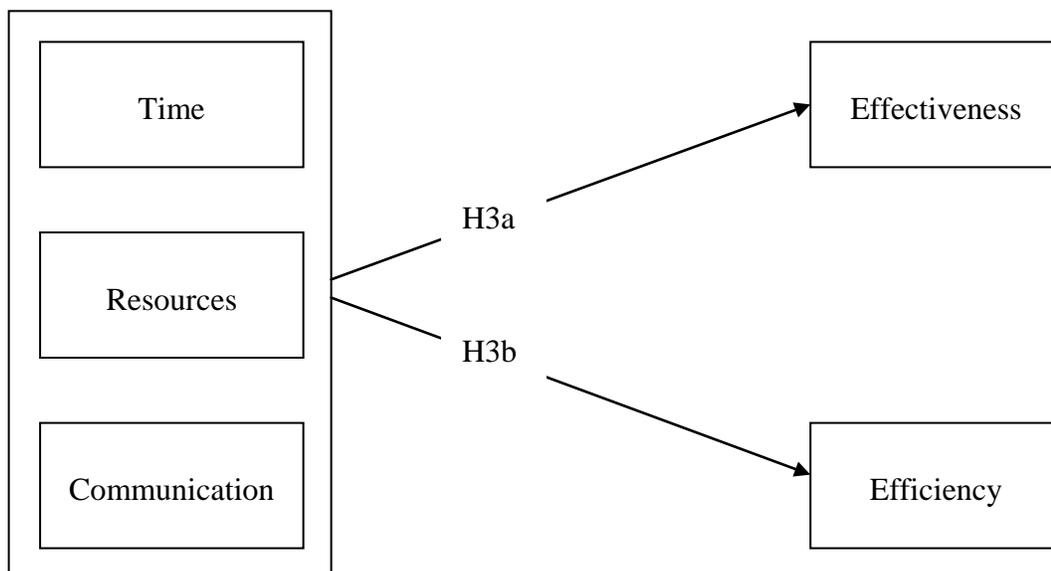


Figure 3-2 Research Hypothesis H3

Table 3-11 Research Hypotheses List for H3

	Hypotheses
<b>H3a</b>	Time, resources, and communication impact effectiveness
<b>H3b</b>	Time, resources, and communication impact efficiency

### 3.5 Survey Creation

The main objective of this study was to empirically evaluate the effectiveness and efficiency of CI training in an organization that was in the beginning stages of CI implementation. This evaluation was aimed at helping determine ways to shape the training to best support this

organization. The findings from this investigation were aimed at understanding what relationship, if any, existed between time, communication, and resources utilized to the overall effectiveness and efficiency of training events as modeled in Figure 3-1. Understanding the factors that impact the effectiveness and efficiency could also be helpful to other organizations interested in developing CI training.

Each independent and dependent variable was further defined through the development of multiple survey items. All survey items were developed to capture the trainees' experiences before, during, and after training. No survey item required reverse coding. Each survey item and its mapping to the research variables are shown in Table 3-12 and Table 3-13. Two survey instruments, Survey A and Survey B, were created with these items. Survey A was aimed at assessing the "before" and "during" stages of the training. Survey B was aimed at assessing training two or more weeks after the training session had been completed.

Table 3-12 Survey Item and Item Codes for Independent Variables

	<b>Item Code</b>	<b>Survey item</b>
<b>Time</b>	T1-A	Time was well spent throughout the entire training session
	T2-A	Sufficient time was allowed for training
	T3-A	Sufficient time was provided to explain each topic
	T4-A	Sufficient time was allocated to practicing each tool
	T5-A	The trainer was able to keep the training session within the allotted time frame
<b>Communication</b>	C1-A	I was informed about my participation in this training event prior to the day of the training
	C2-A	I knew what to expect out of the training before I arrived
	C3-A	I am confident I can communicate with my immediate supervisor about the material that was covered during the training
	C3-B	I have been able to communicate with my immediate supervisor about the material that was covered during the training
	C4-A	The trainer gave clear explanations
	C4-B	I have been able to contact the trainer since the training event
	C5-A	I understood the objectives of the training from the beginning
<b>Resources</b>	R1-A	I found the learning tools used during this training helpful
	R2-A	I had all the tools on hand I needed to help me understand the material
	R3-A	The training material was easy to follow
	R4-A	The training material was consistent
	R5-A	The presentation was consistent with the handouts
	R6-A	The presentation of the material helped me complete the exercises
	R7-B	I have referred back to a copy of the training material
	R8-B	I have shared a copy of the training material with co-workers who have not yet participated in similar training

Note. "A" represents Survey A and "B" represents Survey B

Table 3-13 Survey Item and Item Codes for Dependent Variables

<b>Effectiveness</b>	E1-A	I expect to positively impact my work area as a result of what I learned in this training
	E1-B	I have noticed a positive impact in my work area as a result of what I learned in this training
	E2-A	The tools taught in this training will help improve the performance of my work area
	E2-B	The tools taught in this training have helped improve the performance of my work area
	E3-A	I will be able to use the tools taught in this training in my work environment
	E3-B	I have been able to use the tools taught in this training in my work environment
	E4-A	I plan to use the tools I learned in training in my work environment
	E4-B	I have used the tools I learned in training in my work environment
	E5-B	I have recommended co-workers to go through similar training
<b>Session Efficiency</b>	SE1-A	The training session was well organized
	SE2-A	The trainer was organized
	SE3-A	The trainer was prepared
	SE4-A	I was able to work with my peers to better understand the material taught in this training
	SE5-A	I was able to ask my instructor questions to get a better understanding of the training material
	SE6-A	I was able to complete all exercises

All survey items were evaluated using a 5-point Likert Scale. The scale values used were as follows:

- 1 = Strongly Disagree
- 2 = Disagree
- 3 = Neutral
- 4 = Agree
- 5 = Strongly Agree

The order of items on Survey A and B was determined by utilizing 35 equally sized pieces of paper, which were cut out (roughly 2 square inches in size) with the code for each survey statement written on them. Each piece of paper was then folded 2 times and put into a box. The

box was shaken to randomize the pieces. Each piece of folded paper was randomly selected one at a time. The order of items in the survey was determined based on this randomly selected order.

### 3.6 Survey administration and collection

The following section goes through the steps of participant selection, scheduling of the surveys, additional survey paperwork, and the survey collection process.

#### 3.6.1 *Participant Selection*

All employees who participated in CI training at the field study site during the investigation period were asked to complete the survey. The Training Manager at the field study site was in charge of selecting training participants. Employees who participated in training at the field study site represented all levels and include both executives and front-line employees. There were some challenges with the arrangement of a time to distribute the surveys to the participants due to the dynamics schedules of the participants. Most of these problems arose when trying to coordinate with front-line personnel.

#### 3.6.2 *Scheduling Surveys*

All CI training was coordinated in advance with each particular trainer and with the assistance of the Training Manager at the field study site. After each employee completed a training session related to the implementation of CI tools, they were asked to voluntarily complete Survey A and Survey B for that particular training session. Survey A was distributed directly after the training had been completed and focused solely on evaluating the training session which just took place. Survey B was focused on the same training session as Survey A. Survey B focused on the impact the work area and was distributed at the same time as Survey A. A number was assigned to each

set of surveys to help match Survey A and Survey B data. Once numbered, the blank surveys were mixed up, as to reduce the chance of any survey being traced back to the identity of the employees participating. The student researcher or trainer introduced the surveys to participants by reading a script (see Appendix C). The surveys were then handed out to the participants.

### *3.6.3 Additional Survey Paperwork*

The surveys also included a cover letter that could be detached and retained by the participant. The cover letter acted as the waiver of informed consent. The cover letter provided information about the study, participant rights, confidentiality, instructions on completing the survey, directions as to where to return the completed surveys, and contact information for the principal investigator, student researcher, and the Institutional Review Board (IRB). Upon reading the cover letter, participants could decide whether or not to fill out Survey A and/or Survey B. A copy of the questions was available for the trainee to keep, upon request. The surveys used for this study, Survey A and Survey B, are included in Appendix E and Appendix F, respectively.

### *3.6.4 Survey Collection*

Each survey was designed to take no longer than 15 minutes to complete. Participants could choose to complete Survey A immediately upon receiving it and turn it in to the student researcher or to complete the survey in private and return it to a designated locked box, which was accessible to all employees seven days a week and 24 hours a day. Survey B which was to be completed at least two weeks after the training has been completed was turned in at the lock

box. The participants were instructed to turn in Survey B two or more weeks after the training had been completed.

### 3.7 Analysis Details

The following section explains the various analyses methods used for this study. Analyses were completed using IBM ® analytical software, Statistical Package for the Social Sciences® (SPSS version 18). First, Cronbach's Alpha values were used to evaluate the internal reliability of the survey items used to operationalize each variable. Ordinary least squares (OLS) regression models were used next to test the relationship between each independent variable (IV) and each dependent variable (DV). An Analysis of Variance (ANOVA) was completed third to check for differences in responses that might exist due to differences in various demographic factors that were not controlled for in the study. The final analysis completed was regression analysis. Multiple regression analysis was used to identify the most significant independent variables in explaining observed variation in training effectiveness and efficiency. Assumptions for the various models were also checked.

#### 3.7.1 *Cronbach's Alpha*

Cronbach's Alpha values were calculated to ensure that each survey items was robust enough to reliable measure the IV's and DV's of interest. Cronbach's Alpha is a measure of internal consistency (Hayes, 1992; Muchinsky, 1997; Nunnally, 1978) and can be calculated using Equation 3 (Bland & Altman, 1997).

$$\alpha = \frac{K}{K-1} \left( 1 - \frac{\sum_{i=1}^K s_i^2}{s_T^2} \right) \quad (3)$$

Where:

K = number of items

$s_i^2$  = variance of the  $i$ th item

$s_T^2$  = variance of the total score formed by summing all the items

Cronbach's Alpha is a measure of the squared correlation between observed scores and actual scores. Put another way, reliability is measured in terms of the ratio of true score variance to observed score variance. According to (Nunnally, 1978, p. 245), "In the early stages of research on predictor tests or hypothesized measures of a construct, one saves time and energy by working with instruments that have only modest reliability, for which purpose reliabilities of .70 or higher will suffice."

### 3.7.2 *Linear Regression*

Ordinary least squares (OLS) regression models were used to test the relationship between each IV and DV.

#### 3.7.2.1 *Linear Regression Assumption*

Assumptions related to linear regression were checked prior to analysis. These assumptions include the need for linearly related data, constant variance of error terms, normally distributed residuals with a mean of 0, and error terms are statistically independent.

### 3.7.2.2 Ordinary Least Square

OLS utilizes a method that minimizes the sum of the squared difference between observed values and predicted values from a linear approximation for a particular data set. For each OLS model three values,  $R$ ,  $R^2$  and  $R^2_{adjusted}$  were calculated. These values provide a correlation between observed and predicted values for each dependent variable value. The value of  $R^2$  is interpreted as the proportion of total variation in a dependent variable accounted for by an independent variable included in the regression model. The value of  $R^2_{adjusted}$  is used to compensate for the overestimation of the population parameter. The equation used to calculate  $R^2_{adjusted}$  is shown in Equation 4.

$$R^2_{adjusted} = R^2 - \frac{p(1-R^2)}{N-p-1} \quad (4)$$

Where:

$p$  = number of independent variables

$N$  = sample size

$$R^2 = 1 - \frac{\text{residual sum of squares}}{\text{total sum of squares}}$$

### 3.7.3 ANOVA

ANOVA was completed for each category of occupational and training demographic information. ANOVA was used to determine if there was a significant difference in variance between the various groups of respondents ( $p > 0.05$ ).

### 3.7.4 Multiple Regression

After completing the individual regression for each independent and dependent variable pair and the ANOVA analyses, a multiple regression model was built. This analysis focused on creating a descriptive model in an attempt to identify the most significant independent variable(s). An assessment of collinearity was conducted to quantify the extent to which the variance of estimated regression coefficients was increased due to collinearity. This assessment was completed using Pearson correlation coefficients, as well as Variance Inflation Factors (VIF).

#### 3.7.4.1 Correlation Analysis

Correlation coefficients were calculated to determine the extent of the relationship existing between all IV and DV pairs. Pearson correlation coefficients were calculated using Equation 5.

$$r_{xy} = \frac{\sum_{i=1}^n (x_j - \bar{x})(y_j - \bar{y})}{(n-1)s_x s_y} \quad (5)$$

Where:

$n$  = number of pairs of values

$\bar{x}$  = the sample means of X

$\bar{y}$  = the sample means of Y

$s_x$  = sample standard deviation of X

$s_y$  = sample standard deviation of Y

### 3.7.4.2 VIF

VIF measures the extent to which regression parameter variance for the  $k^{\text{th}}$  independent variable is inflated when another variable is included in the regression. The VIF is calculated using Equation 6.

$$VIF = \frac{1}{1-R_j^2} \quad (6)$$

Where:

$R_j^2$  = squared multiple correlation of variable  $j$  with another independent variable.

### 3.7.4.3 Multiple Regression Model

Multiple regression models were built using a backward elimination procedure. Equation 7 represents the general multiple regression model.

$$Y_i = \beta_0 + \sum_{j=1}^p \beta_j X_{i,j} + \varepsilon_i \quad (7)$$

Where, for the  $i^{\text{th}}$  case:

$X_{i,j}, \dots, X_{i,p}$  =  $p$  regressors for independent variables

$\beta_0, \dots, \beta_p$  = unknown coefficients (values determined by least square)

$\varepsilon_i$  = mean error term

The backwards elimination procedure was selected since it is less likely to result in the removal of important variables than forward or stepwise selection procedures (Neter, Wasserman, Kutner, & Li, 1996). The p-value corresponding to the F statistic is the criterion used to determine if a

variable should be added or deleted. The backwards elimination process starts with all potential independent variables initially entered into the model. The variable with the largest p-value  $> 0.05$  is eliminated. This process is repeated until all p-values  $\leq 0.05$  for all independent variables.

## **4 Results**

This chapter discusses the results of the data analysis used to test all hypotheses. First, Cronbach's Alpha values were calculated to determine internal reliability. Ordinary least squares (OLS) regression models were used next to test the relationship between each independent variable (IV) and each dependent variable (DV). An Analysis of Variance (ANOVA) was completed third to check for differences in responses that might exist due to different in various demographic factors that were not controlled for in the study. The final analysis completed was regression analysis. Multiple regression was used to identify the most significant independent variables in explaining observed variation in training effectiveness and efficiency. Assumptions for the various models were checked and the results are summarized.

### **4.1 Compiled Data**

The analysis of data began by entering each response into a single Microsoft Excel 2007 spreadsheet. Averages for each variable were calculated and are summarized in Table 4-1. Additional information for each trainee was also collected and entered into this spreadsheet, i.e., occupational specialty, current training completed, and previous training courses completed, as seen in Table 4-2.

Table 4-1 Averages of Results

<b>Participant Number</b>	<b>Communication Average</b>	<b>Resources Average</b>	<b>Efficiency Average</b>	<b>Time Average</b>	<b>Effectiveness Average</b>
<b>1</b>	2.86	2.63	3.00	2.80	2.78
<b>2</b>	4.00	3.50	3.83	3.20	4.22
<b>3</b>	3.71	3.38	4.00	4.40	4.44
<b>4</b>	3.14	3.75	3.83	3.60	3.78
<b>5</b>	3.86	3.25	4.33	4.00	3.78
<b>6</b>	4.71	4.50	4.67	4.40	4.89
<b>7</b>	3.57	3.50	3.67	3.60	3.89
<b>8</b>	3.86	3.71	4.50	4.00	3.44
<b>9</b>	3.67	4.00	4.00	3.33	4.00
<b>10</b>	4.17	4.00	4.00	4.00	4.33
<b>11</b>	3.71	3.88	4.17	3.80	3.67
<b>12</b>	3.43	3.50	4.00	3.40	3.78
<b>13</b>	4.00	3.88	4.50	4.00	3.44
<b>14</b>	4.14	4.13	4.33	4.00	4.44
<b>15</b>	3.00	3.75	4.00	3.20	3.78
<b>16</b>	3.29	3.75	4.00	3.40	3.67
<b>17</b>	3.86	3.63	4.00	3.80	4.00
<b>18</b>	3.00	3.00	3.75	4.00	2.89
<b>19</b>	3.43	3.00	3.50	3.00	2.22
<b>20</b>	3.71	3.50	3.50	3.80	3.78
<b>21</b>	3.29	2.50	3.00	3.00	2.56
<b>22</b>	3.00	4.13	3.50	2.80	3.67
<b>23</b>	3.00	3.00	3.50	3.60	2.75
<b>24</b>	3.71	4.00	4.17	3.80	4.56
<b>25</b>	3.43	3.38	3.67	3.40	3.88
<b>26</b>	2.86	2.88	2.83	2.80	2.67
<b>27</b>	2.86	3.50	4.33	3.75	3.33
<b>28</b>	3.43	3.63	3.67	4.00	3.56
<b>29</b>	2.71	3.00	3.83	2.40	2.33

Table 4-2 Occupational and Training Specifics for Trainees

<b>Participant Number</b>	<b>Occupational Specialty</b>	<b>Current Training Evaluated</b>	<b>Previous Training(s) Completed</b>
1	Manager	RCA	A3, 5S
2	Other	A3	RCA
3	Other	5S	A3
4	Not Specified	Not Specified	None
5	Manager	5S	A3, 5S
6	Manager	5S	A3
7	Manager	5S	5S
8	Manager	A3, RCA	A3
9	Manager	5S	A3, RCA
10	Manager	5S	A3
11	Manager	n/a	A3
12	Manager	A3	A3
13	Other	A3	None
14	Manager	A3	Other
15	Safety	RCA	A3, 5S
16	Manager	Taproot®	A3, RCA
17	Manager	RCA	A3, 5S
18	Manager	RCA	5S, visuals
19	Shop Floor	5S	None
20	Shop Floor	5S	None
21	Manager	RCA	A3, 5S
22	Other	RCA	5S
23	Other	5S	None
24	Safety	RCA	5S
25	Not Specified	5S	None
26	Other	5S	RCA
27	Other	RCA	5S
28	Manager	RCA	A3, lean mfr
29	Manager	RCA	A3

## 4.2 Cronbach's Alpha

Cronbach's alpha values for each IV and DV are summarized in Table 4-3.

Table 4-3 Cronbach's Alpha Values

<b>Variable</b>	<b>Number of items</b>	<b>Initial Cronbach's Alpha Value</b>	<b>Improved Cronbach's Alpha Value</b>
<b>Time</b>	5	0.594	0.742
<b>Resources</b>	8	0.772	0.776
<b>Communication</b>	7	0.523	0.540
<b>Effectiveness</b>	9	0.929	0.934
<b>Efficiency</b>	6	0.754	0.799

Two of the Cronbach's values were initially less than 0.70 increased. Both values increased by more than 0.01 when one item from each variable was removed. See Table 4-4. These sets of items are shown in Table 4-5.

Table 4-4 Improved Cronbach's Alpha Values

<b>Variable</b>	<b>Item Deleted</b>	<b>New number of items</b>	<b>Increase in Cronbach's Alpha Value</b>
<b>Time</b>	<b>T5-A</b>	4	<b>0.148</b>
<b>Resources</b>	R5-A	7	0.004
<b>Communication</b>	<b>C3-A</b>	6	<b>0.017</b>
<b>Effectiveness</b>	UC3-A	8	0.005
<b>Efficiency</b>	SE4-A	5	0.045

Item T5-A was removed from the analysis. A close look at the item T5-A revealed that unlike other items in the time variable, this item evaluated the trainer not the training itself, possibly explaining the resulting lower reliability. Item C3-A was eliminated from the communication variable. After a closer look at this item, it was observed that the structure of the item required

the respondent to express a level of confidence rather than assess certainty about specific abilities. In addition, the item also may have been influenced by previously existing relationships with a supervisor, thus not reflecting an assessment of only the impact of communication. This finding is further supported by looking at the initial interviews conducted in which employees stated that the “quality of relationship between trainer and trainee” (as stated by 10 out of 18 interviewees) was seen to impact the effectiveness of the training session. The survey created included seven items specific to the variable of communication.

The improved Cronbach’s alpha value for communication was below the accepted value of 0.70. This was mostly due the small number of survey items for the variable of communication. The limited number of survey items made it difficult to accurately capture communication before, during, and after training. Three of the survey items were focused on communication before training, one item was focused on communication during training, and three items were focused on communication after training. The broad range of communication survey items made it so consistency in responses to survey items was low, which is confirmed with a low Cronbach’s alpha value for the variable of communication. The low Cronbach’s alpha value made researchers more cautious when interpreting the results which included the variable of communication.

Table 4-5 Revised Survey Item for Time and Communication (items in bold were eliminated from the final set of data analyzed)

	<b>Item Code</b>	<b>Survey item</b>
<b>Time</b>	T1-A	Time was well spent throughout the entire training session
	T2-A	Sufficient time was allowed for training
	T3-A	Sufficient time was provided to explain each topic
	T4-A	Sufficient time was allocated to practicing each tool
	<b>T5-A</b>	<b>The trainer was able to keep the training session within the allotted time frame</b>
<b>Communication</b>	C1-A	I was informed about my participation in this training event prior to the day of the training
	C2-A	I knew what to expect out of the training before I arrived
	<b>C3-A</b>	<b>I am confident I can communicate with my immediate supervisor about the material that was covered during the training</b>
	C3-B	I have been able to communicate with my immediate supervisor about the material that was covered during the training
	C4-A	The trainer gave clear explanations
	C4-B	I have been able to contact the trainer since the training event
	C5-A	I understood the objectives of the training from the beginning

### 4.3 Linear Regression

Ordinary Least Square (OLS) Regression was performed to evaluate the nature of the relationships between each IV and DV. Before the analysis was completed, all assumptions related to performing OLS were checked. Lastly, the linear regression was calculated.

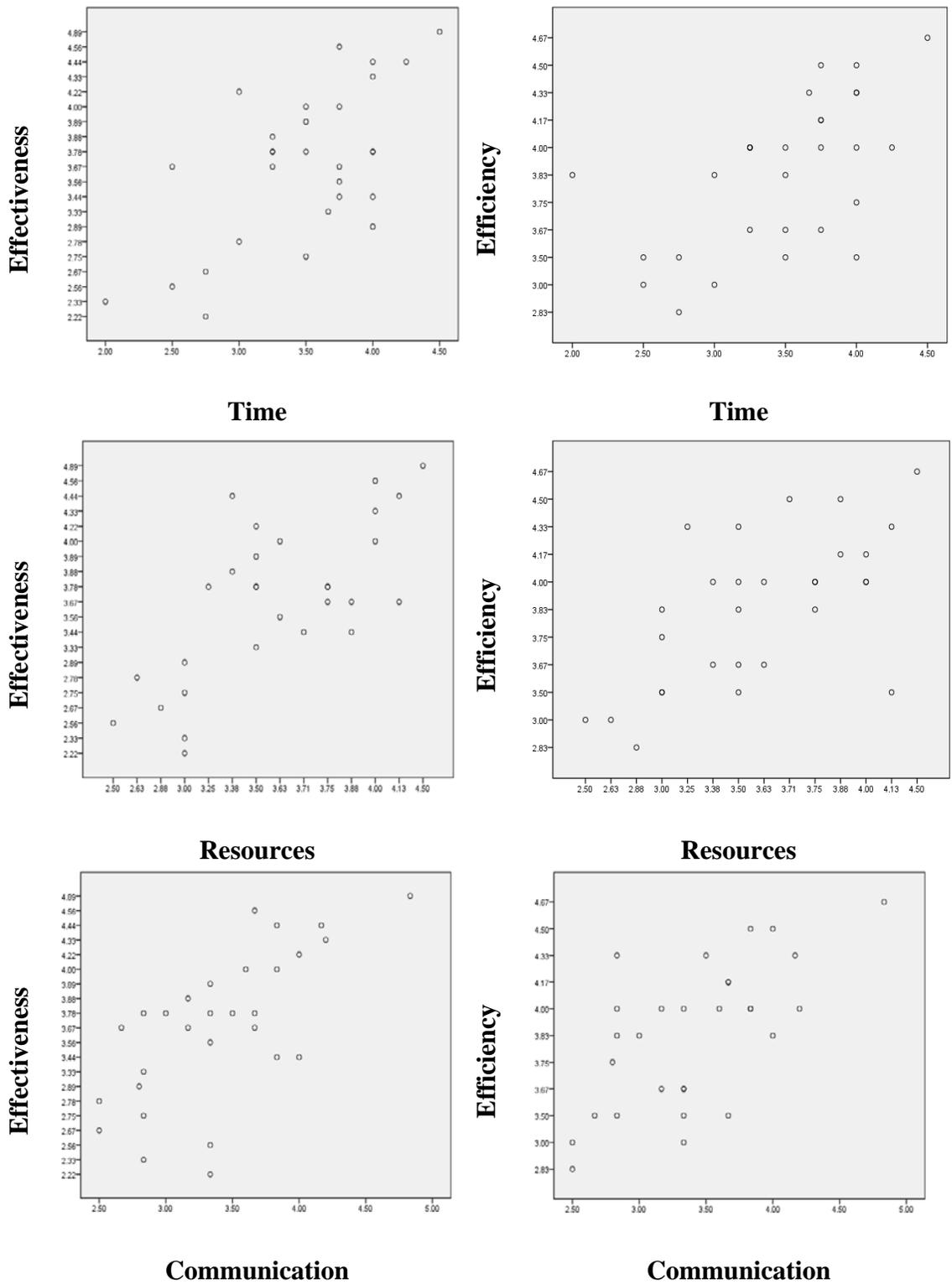
#### *4.3.1 OLS Assumption Checking*

Assumptions related to linear regression were checked prior to analysis. These assumptions include the need for linearly related data, constant variance of error terms, normally distributed residuals with a mean of 0, and error terms are statistically independent.

##### *4.3.1.1 Linearity*

The linearity assumption was checked using scatter plots. Scatter plots for each IV against each DV are included in Figure 4-1. The scatter plots illustrate that for all pairs of IV's and DV's, the data appear to be linearly related.

Figure 4-1 Scatter Plots of each IV DV pair



#### 4.3.1.2 *Homoscedasticity*

The assumption of homoscedasticity assumes that the observed variance of residuals is homogeneous across all levels, i.e.,  $\text{Var}[\varepsilon_i | x_i] = \sigma^2$ . Homoscedasticity was checked by examining plots of residuals versus predicted values (see Figure 4-2 and Figure 4-3). This assumption is important to check as heteroscedasticity may result in incorrect estimates of the variance of the coefficients to be biased. To verify homoscedasticity, studentized residuals should have a mean of 0 and a variance of 1. Most (95%) of the residuals should fall between -2 and +2 (Pagano, 2008). In addition, no patterns should be observable in a plot of the residuals. As seen in Figure 4-2 and Figure 4-3, the assumption of homoscedasticity was reasonably met for each IV versus DV.

Figure 4-2 Plot of Residuals versus Fitted Values for Effectiveness

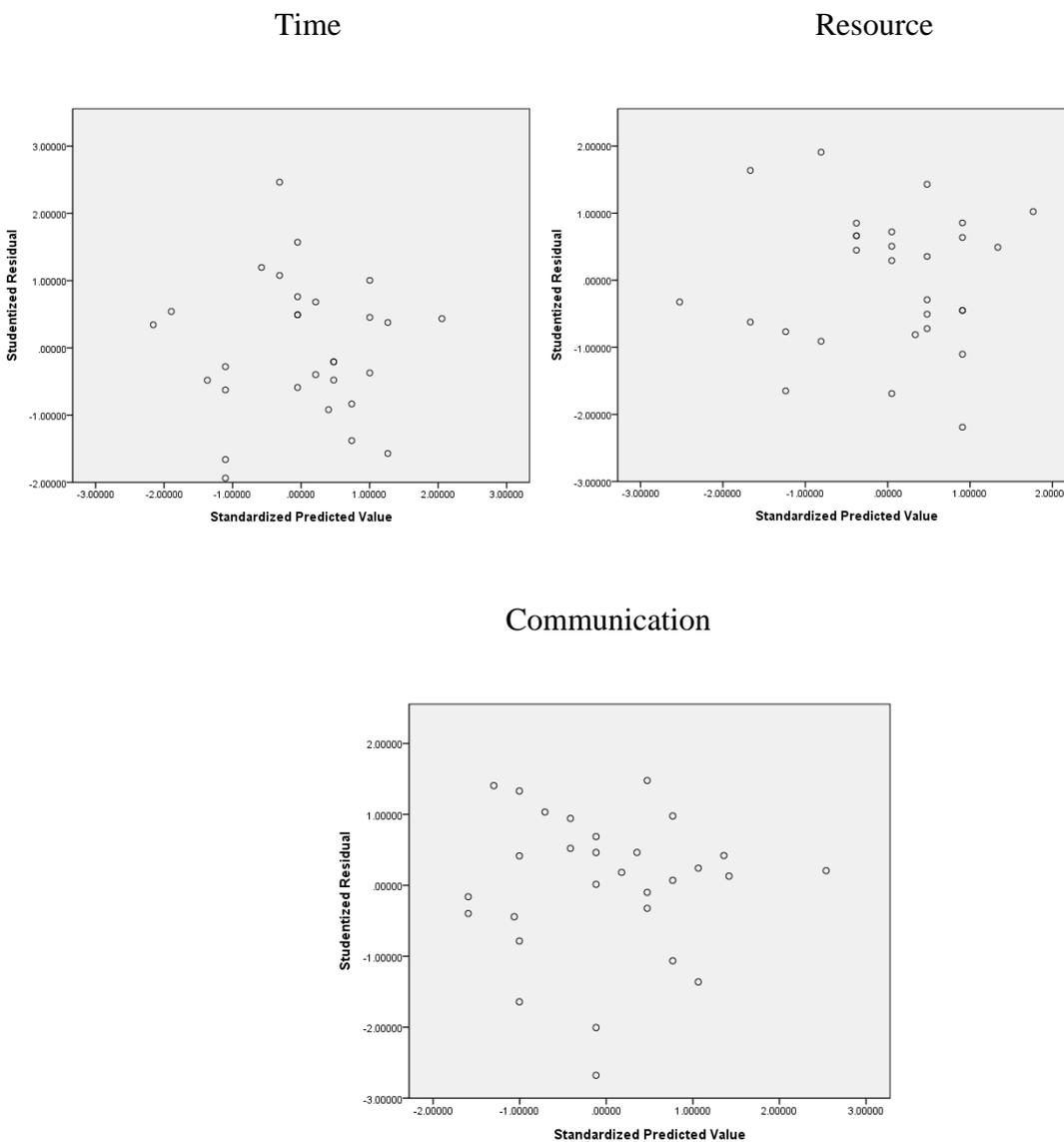
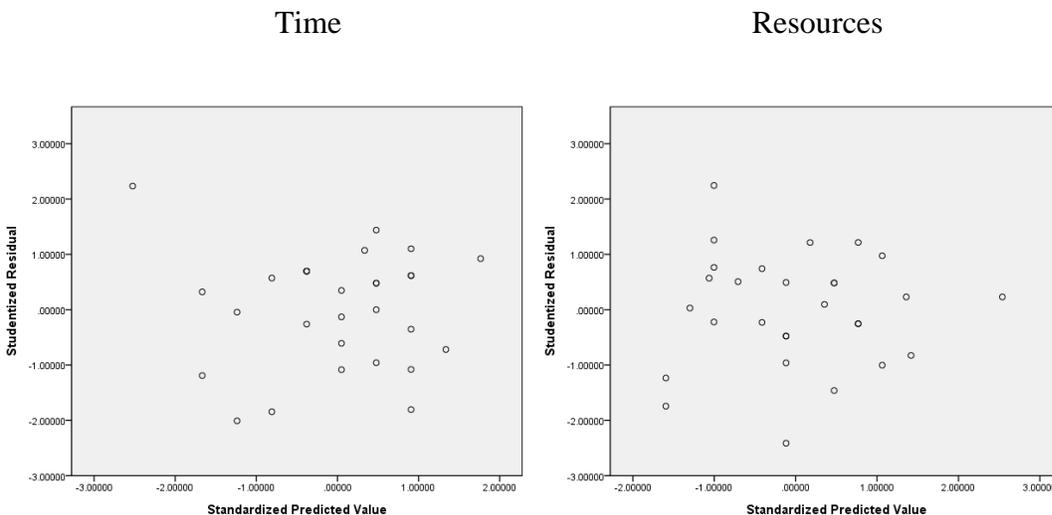
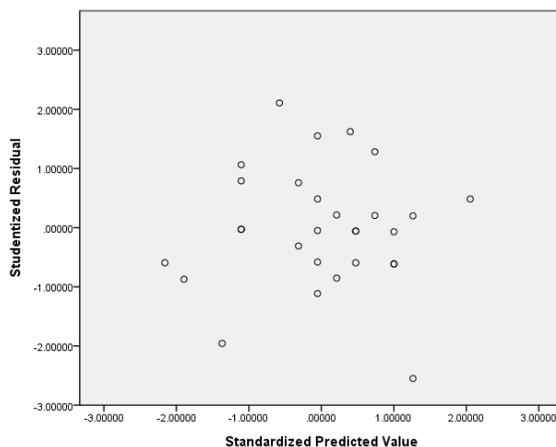


Figure 4-3 Plot of Residuals versus Fitted Values for Efficiency



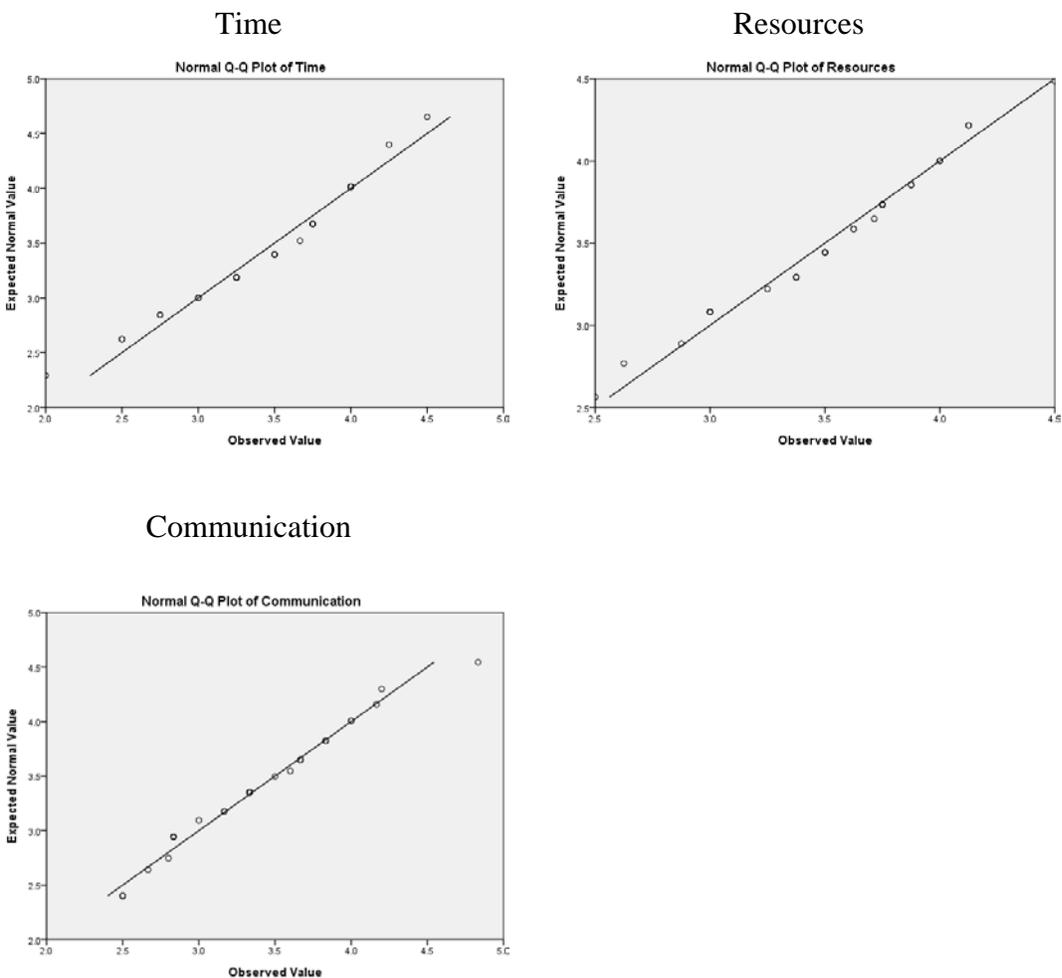
Communication



4.3.1.3 Normality of Residuals

The normality of the error terms is examined by looking at Q-Q plots of the residuals. The Q-Q plots should show the points close to the line. Q-Q plots for each independent variable can be seen in Figure 4-4. The assumption of normality appears to be reasonable.

Figure 4-4 Q-Q Plots for Independent Variables



#### 4.3.1.4 Independence

The last assumption is that errors are statistically independent. The data collected in this research was done in such a way to ensure independence. The participants were obtained from a sample of employees who had been through various types of CI training. In conclusion, all four assumptions for OLS were met.

### 4.3.2 Linear Regression Analysis

The linear regression analysis was used to create a descriptive model, i.e., to determine if independent variables could be used to explain the observed variation for each dependent variable. This model is not intended to act as a predictive model. The linear regression coefficients, standard errors, and p-values are shown in Table 4-6.

Table 4-6 Linear Regression Coefficients

Dependent Variable	Model	Unstandardized Coefficients		Standardized Coefficients	t	p-value
		$\beta$	Std. Error	Beta		
Effectiveness	(Constant)	.953	.602		1.583	.125
	Time	.764	.171	.651	4.459	.000
Efficiency	(Constant)	2.181	.405		5.379	.000
	Time	.485	.115	.629	4.208	.000
Effectiveness	(Constant)	-.445	.593		-.751	.459
	Resources	1.149	.167	.798	6.889	.000
Efficiency	(Constant)	1.470	.450		3.265	.003
	Resources	.679	.127	.718	5.365	.000
Effectiveness	(Constant)	.768	.581		1.322	.197
	Communication	.834	.169	.689	4.942	.000
Efficiency	(Constant)	2.127	.404		5.265	.000
	Communication	.511	.117	.643	4.359	.000

The following equations were derived using the linear regression coefficients. As summarized in Equation 8, Equation 9, and Equation 10, the slope is greatest for resources, followed by communication and lastly time.

$$\text{Effectiveness} = 0.953 + 0.764 \cdot \text{Time} \quad (8)$$

$$\text{Effectiveness} = -0.445 + 1.149 \cdot \text{Resources} \quad (9)$$

$$\text{Effectiveness} = 0.768 + 0.834 \cdot \text{Communication} \quad (10)$$

As summarized in Equation 11, Equation 12, and Equation 13, efficiency is impacted the most by resources, followed by communication and lastly time.

$$\text{Efficiency} = 2.181 + 0.485 \cdot \text{Time} \quad (11)$$

$$\text{Efficiency} = 1.470 + 0.679 \cdot \text{Resources} \quad (12)$$

$$\text{Efficiency} = 2.127 + 0.511 \cdot \text{Communication} \quad (13)$$

The  $R^2$  and  $R^2_{adjusted}$  values are summarized in Table 4-7.

Table 4-7 Linear Regression R Values

<b>Independent Variable</b>	<b>Dependent Variable</b>	<b>R</b>	<b>R Square</b>	<b>Adjusted R Square</b>
Time	Effectiveness	.651 <sup>a</sup>	.424	.403
Time	Efficiency	.629 <sup>a</sup>	.396	.374
Resources	Effectiveness	.798 <sup>b</sup>	.637	.624
Resources	Efficiency	.718 <sup>b</sup>	.516	.498
Communication	Effectiveness	.689 <sup>c</sup>	.475	.456
Communication	Efficiency	.643 <sup>c</sup>	.413	.391

a. Predictors: (Constant), Time

b. Predictors: (Constant), Resources

c. Predictors: (Constant), Communication

When each IV was considered separately, time explained 40% of the observed variation in effectiveness and 37.4% of the observed variation in efficiency. Resources explained 62.4% of

the variance of effectiveness and 49.8% of the variance for efficiency. Communication explained 45.6% of the variation of effectiveness and 39.1% of the variation for efficiency.

#### 4.4 ANOVA

In order to conduct the Analysis of Variance (ANOVA), data related to job junctions and previous training was coded as outlined in Table 4-8. Table 4-9 shows the coded data by participant. A coding system using 0, 1, and 2 was used. Occupational specialty was coded to distinguish between managers and non-managers (i.e. other). Current training was coded to distinguish between 5S and root cause analysis training (RCA). The RCA training encompassed both A3 and Taproot® training. Both of these trainings focused on root cause analysis principles. Previous training was split into three categories. These categories were established to distinguish between participants who had no previous training, a single previous training experience, and those with more than one training experience. Some participants did not provide information for these questions. Participants not providing information were not included in the ANOVA.

Table 4-8 Coding Scheme for Data

<b>Code</b>	<b>Occupational specialty</b>	<b>Current training</b>	<b>Previous training</b>
0	Other	5S	None
1	Manager	RCA, A3, Taproot®	1 training event
2			>1 training event

Table 4-9 Coded Data for Occupational and Training Specifics for each Respondent

<b>N</b>	<b>Occupational specialty</b>	<b>Current Training</b>	<b>Previous training</b>
1	1	1	2
2	0	1	1
3	0	0	1
4	N/A	N/A	0
5	1	0	2
6	1	0	1
7	1	0	1
8	1	1	1
9	1	0	2
10	1	0	1
11	1	N/A	1
12	1	1	1
13	0	1	0
14	1	1	0
15	0	1	2
16	1	1	2
17	1	1	2
18	1	1	2
19	0	0	0
20	0	0	0
21	1	1	2
22	0	1	1
23	0	0	0
24	0	1	1
25	N/A	0	0
26	0	0	1
27	0	1	1
28	1	1	2
29	1	1	1

ANOVA was completed for each category. ANOVA was used to determine if there was a significant difference in responses between these groups. No significant difference between groups was found ( $p>0.05$ ) for any of the DVs or IVs for the three different demographic factors tested. The groups for the Occupation category were “manager” and “other”. The ANOVA results for the category of Occupation are shown in Table 4-10.

Table 4-10 ANOVA for Occupation

		<b>ANOVA</b>				
		Sum of Squares	df	Mean Square	F	p-value
Time	Between Groups	.110	1	.110	.294	.593
	Within Groups	9.343	25	.374		
	Total	9.453	26			
Resources	Between Groups	.009	1	.009	.035	.852
	Within Groups	6.227	25	.249		
	Total	6.236	26			
Communication	Between Groups	.341	1	.341	1.021	.322
	Within Groups	8.352	25	.334		
	Total	8.693	26			
Effectiveness	Between Groups	.055	1	.055	.107	.746
	Within Groups	12.899	25	.516		
	Total	12.955	26			
Efficiency	Between Groups	.136	1	.136	.622	.438
	Within Groups	5.466	25	.219		
	Total	5.602	26			

The groups for the Current Training category were “5S” and “RCA”. The ANOVA results for the category of Current Training are shown in Table 4-11. No significant difference between groups was found for the Current Training category, i.e.  $p>0.05$ .

Table 4-11 ANOVA for Current Training

		<b>ANOVA</b>				
		Sum of Squares	df	Mean Square	F	p-value
Time	Between Groups	.578	1	.578	1.634	.213
	Within Groups	8.844	25	.354		
	Total	9.422	26			
Resources	Between Groups	.004	1	.004	.016	.899
	Within Groups	6.120	25	.245		
	Total	6.124	26			
Communication	Between Groups	.278	1	.278	.826	.372
	Within Groups	8.413	25	.337		
	Total	8.690	26			
Effectiveness	Between Groups	.178	1	.178	.347	.561
	Within Groups	12.851	25	.514		
	Total	13.030	26			
Efficiency	Between Groups	.083	1	.083	.382	.542
	Within Groups	5.466	25	.219		
	Total	5.550	26			

The groups for the Previous Training category was used to specify the number of previous training sessions each respondent had completed. Respondents had no previous related training, one previous related training course, or two or more previous related training courses. The ANOVA results for the category of Previous Training are shown in Table 4-12. No significant difference between groups was found for the Previous Training category, i.e.  $p > 0.05$ .

Table 4-12 ANOVA for Previous Training

		<b>ANOVA</b>				
		Sum of Squares	df	Mean Square	F	p-value
Time	Between Groups	.093	2	.046	.128	.880
	Within Groups	9.411	26	.362		
	Total	9.504	28			
Resources	Between Groups	.492	2	.246	1.098	.348
	Within Groups	5.818	26	.224		
	Total	6.310	28			
Communication	Between Groups	.477	2	.239	.734	.489
	Within Groups	8.445	26	.325		
	Total	8.922	28			
Effectiveness	Between Groups	.787	2	.393	.833	.446
	Within Groups	12.279	26	.472		
	Total	13.066	28			
Efficiency	Between Groups	.247	2	.124	.595	.559
	Within Groups	5.397	26	.208		
	Total	5.645	28			

#### 4.5 Multiple Regression

After completing pairwise linear regressions and ANOVA analyses, a multiple regression analysis was completed. This analysis focused on creating a descriptive model to test hypotheses H3a and H3b;

- H3a: Time, resources, and communication impact effectiveness
- H3b: Time, resources, and communication impact efficiency

Pearson correlation coefficients and variance inflation factors (VIF) were calculated to quantify the extent of collinearity. Multiple regression models were then built for both effectiveness and efficiency.

#### 4.5.1 Collinearity Analysis

Collinearity of IV was assessed using the Pearson correlation coefficients and variance inflation factors (VIF). A summary of the Pearson correlation coefficients is included in Table 4-13.

Table 4-13 Pearson Correlations Coefficients with P-values for Independent Variables

		Time	Resources	Communication
Time	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	29		
Resources	Pearson Correlation	.510**	1	
	Sig. (2-tailed)	.005		
	N	29	29	
Communication	Pearson Correlation	.626**	.602**	1
	Sig. (2-tailed)	.000	.001	
	N	29	29	29

\*\* . Correlation is significant at the 0.01 level (2-tailed).

There was evidence that the independent variables were correlated. Communication and time had the highest correlation coefficient value of 0.626. Communication and resources had the next highest correlation coefficient value of 0.602. Time and resources had the lowest, yet still significant correlation coefficient value of 0.510.

A summary of VIF is included in Table 4-14.

Table 4-14 VIF Values for Independent Variables

<b>Independent Variable</b>	<b>VIF</b>
Time	1.723
Resources	1.644
Communication	2.000

Table 4.14 shows that standard error for the time coefficients is 1.723 times larger than it would be if time was uncorrelated with resources and communication. In addition, the standard error for resources is 1.644 times larger than it would be if it was uncorrelated with time and communication. Lastly, the standard error for communication is 2.0 times larger than it would be if it was uncorrelated with time and resources. These values are all well below the acceptable VIF value of 10, which is considered to be indicative of severe collinearity. Thus collinearity was not severe (Craney & Surles, 2002).

#### 4.5.2 Multiple Regression - Effectiveness

After checking the level of collinearity, a regression model was created for each dependent variable. A regression model for effectiveness was created first. The  $R^2$  and  $R^2_{adjusted}$  values for the model of effectiveness are shown in Table 4-15. The value of  $R^2$  for the model including all three independent variables is 0.739 and the  $R^2_{adjusted}$  value is 0.708. The value of  $R^2$  for the model including two independent variables is 0.718 and the  $R^2_{adjusted}$  value is 0.696. The  $R^2$  and  $R^2_{adjusted}$  values decrease by a negligible amount when comparing Model 1 to Model 2. In summary, 70.8% of the variation in effectiveness can be explained by communication, resources, and time, while 69.6% of the variation in effectiveness can be explained by resources and time.

Table 4-15 Model Summary for Effectiveness

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.860 <sup>a</sup>	.739	.708	.369
2	.847 <sup>b</sup>	.718	.696	.376

a. Predictors: (Constant), Communication, Resources, Time

b. Predictors: (Constant), Resources, Time

An ANOVA was performed on the model for effectiveness, as seen in Table 4-16. The F-statistic was used to test the hypothesis that the slopes ( $\beta_1, \dots, \beta_p$ ) are 0. The F-statistics is significant for both models indicating that the hypothesis stating that the coefficients are 0 should be rejected.

Table 4-16 ANOVA for Two Models of Effectiveness

Model		Sum of Squares	df	Mean Square	F	p-value
1	Regression	9.659	3	3.220	23.624	.000 <sup>a</sup>
	Residual	3.407	25	.136		
	Total	13.066	28			
2	Regression	9.380	2	4.690	33.083	.000 <sup>b</sup>
	Residual	3.686	26	.142		
	Total	13.066	28			

a. Predictors: (Constant), Communication, Resources, Time

b. Predictors: (Constant), Resources, Time

c. Dependent Variable: Effectiveness

Coefficients for effectiveness are shown in Table 4-17.

Table 4-17 Coefficients for Effectiveness

Model		Unstandardized Coefficients		Standardized Coefficients	t	p-value
		$\beta$	Std. Error	Beta		
1	(Constant)	-1.022	.555		-1.842	.077
	Time	.282	.157	.241	1.797	.084
	Resources	.793	.188	.551	4.209	.000
	Communication	.250	.175	.207	1.430	.165
2	(Constant)	-.935	.562		-1.662	.108
	Time	.387	.142	.330	2.724	.011
	Resources	.907	.174	.630	5.204	.000

a. Dependent Variable: Effectiveness

The final model for effectiveness is summarized in Equation 14. A 3-D plot of time, resources, and effectiveness is shown in Figure 4-5.

$$Effectiveness = -0.935 + 0.387 \cdot Time + 0.907 \cdot Resources \quad (14)$$

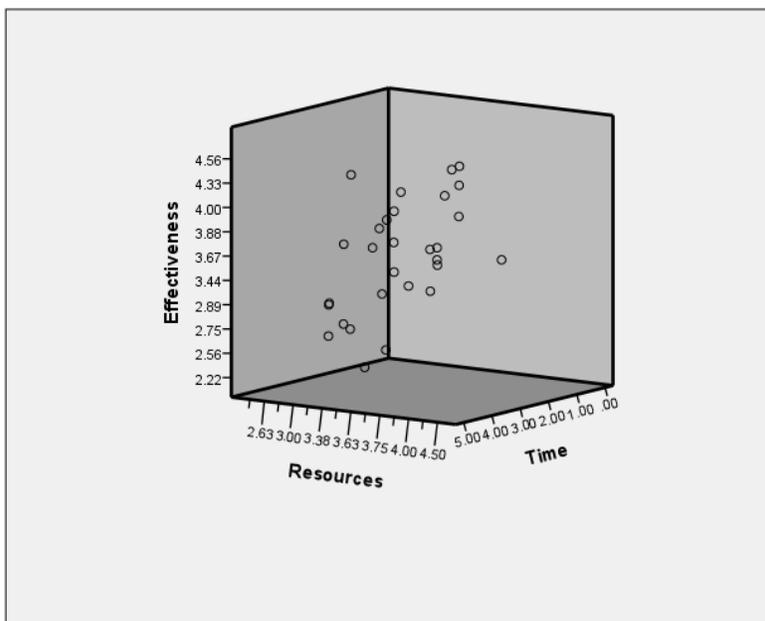


Figure 4-5 3-D Regression Plot for Effectiveness

### 4.5.3 Multiple Regression – Efficiency

A regression model for efficiency was created next. The  $R^2$  and  $R^2_{adjusted}$  values for the model of efficiency are shown in Table 4-18. The value of  $R^2$  for the model including all three independent variables is 0.628 and the  $R^2_{adjusted}$  value is 0.584. The value of  $R^2$  for the model including two independent variables is 0.610 and the  $R^2_{adjusted}$  value is 0.579. The  $R^2$  and  $R^2_{adjusted}$  values decrease by a negligible amount when comparing Model 1 to Model 2. In summary, 58.4% of the variation in efficiency can be explained by communication, resources, and time, while 57.9% of the variation in efficiency can be explained by resources and time.

Table 4-18 Model Summary for Efficiency

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.793 <sup>a</sup>	.628	.584	.289
2	.781 <sup>b</sup>	.610	.579	.291

a. Predictors: (Constant), Communication, Resources, Time

b. Predictors: (Constant), Resources, Time

An ANOVA was performed on the model for efficiency, as summarized in Table 4-19. The F-statistic was used to test the hypothesis that the slopes ( $\beta_1, \dots, \beta_p$ ) were 0. The F-statistic is significant for both models, which indicate that the hypothesis stating that the coefficients are 0 is rejected.

Table 4-19 ANOVA for Efficiency

Model		Sum of Squares	df	Mean Square	F	p-values
1	Regression	3.546	3	1.182	14.084	.000 <sup>a</sup>
	Residual	2.098	25	.084		
	Total	5.645	28			
2	Regression	3.440	2	1.720	20.292	.000 <sup>b</sup>
	Residual	2.204	26	.085		
	Total	5.645	28			

a. Predictors: (Constant), Communication, Resources, Time

b. Predictors: (Constant), Resources, Time

c. Dependent Variable: Efficiency

Coefficients for efficiency are shown in Table 4-20. Using the backwards elimination process, communication was eliminated from the model.

Table 4-20 Coefficients for Efficiency

Model		Unstandardized Coefficients		Standardized Coefficients	t	p-value
		$\beta$	Std. Error	Beta		
1	(Constant)	1.070	.435		2.458	.021
	Time	.210	.123	.272	1.700	.102
	Resources	.438	.148	.463	2.961	.007
	Communication	.154	.137	.194	1.123	.272
2	(Constant)	1.124	.435		2.584	.016
	Time	.274	.110	.355	2.495	.019
	Resources	.508	.135	.537	3.770	.001

a. Dependent Variable: Efficiency

The final model for efficiency is shown in Equation 15. A 3-D plot of time, resources, and efficiency is shown in Figure 4-6.

$$\text{Efficiency} = 1.124 + 0.274 \cdot \text{Time} + 0.508 \cdot \text{Resources} \quad (15)$$

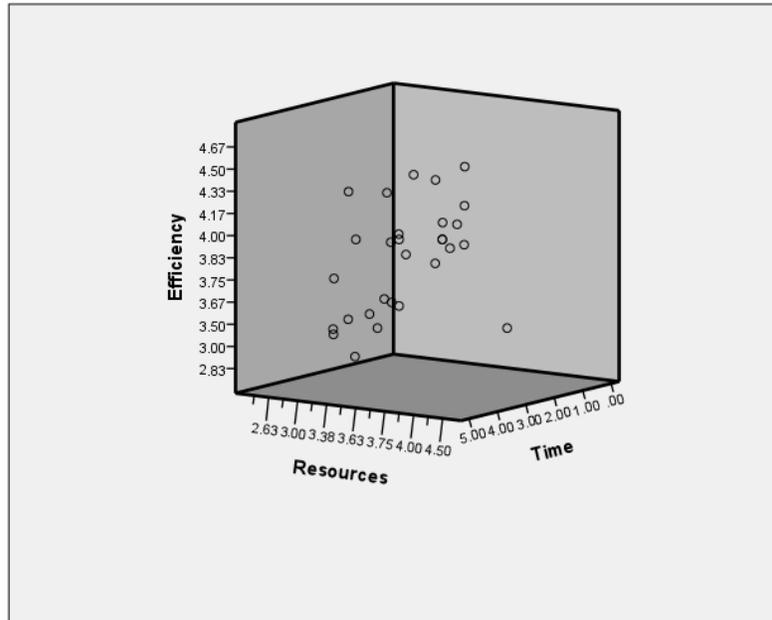


Figure 4-6 3-D Regression Plot for Efficiency

## 5 Discussion and Conclusions

This section presents a summary and discussion of significant findings.

### 5.1 Summary of Significant Findings

Resources were found to have a significant, direct relationship with both effectiveness and efficiency. Communication had a direct relationship with both effectiveness and efficiency. Time had the least significant direct relationship with effectiveness and efficiency. Effectiveness and efficiency were both best explained by time and resources. A discussion of the hypotheses test results from the field study are discussed next.

#### 5.1.1 Discussion of Hypotheses H1a, H1b, and H1c

Hypothesis 1 proposed a direct relationship between each independent variable and effectiveness, as summarized in Table 5-1. The coefficient values, most notably  $\beta_1$ , give an indication of how significant each direct relationship is. There was evidence of a direct relationship between all three independent variables and effectiveness. The model for the relationship between resources and effectiveness appeared to have the greatest impact based on the relative values of  $\beta_1$ . The variable of time showed the smallest effect on the dependent variable effectiveness.

Table 5-1 Research Hypotheses with Coefficient Values for Effectiveness

	Hypotheses	$\beta_0$	$\beta_1$
<b>H1a</b>	Time (T) has a direct relationship with effectiveness	0.953	0.764
<b>H1b</b>	Resources (R) has a direct relationship with effectiveness	-0.445	1.149
<b>H1c</b>	Communication (C) has a direct relationship with effectiveness	0.768	0.834

The results suggest that trainees believe that the influence of the trainer and tools is very important to the delivery of effective continuous improvement training. The training was effective when the tools provided during training were helpful and when the trainee could refer back to the material after training. An additional effect of providing the proper tools was that the trainees were able to utilize the training material to help share knowledge with co-workers. The relationship between communication and effectiveness suggests that managers, trainers, and trainees should communicate expectations before training. Trainers should also continue to communicate with managers and trainees after the training is complete. Time had the smallest effect (based on the value of  $\beta_1$ ) on effectiveness of the three tested variables. However, a significant relationship was found, and thus supports the importance of allocating sufficient time for both explanation and practice, if an effective training session is desired.

### 5.1.2 Discussion of Hypotheses H2a, H2b, and H2c

Hypothesis 2 proposed a direct relationship between each independent variable and efficiency, as summarized in Table 5-2. Similar to Hypothesis 1, all three independent variables showed a direct relationship with efficiency. The variable resources had the highest  $\beta_1$  value. The variable of time had the smallest  $\beta_1$  value in the linear models for the efficiency of continuous improvement training.

Table 5-2 Research Hypotheses with Coefficient Values for Efficiency

	Hypotheses	$\beta_0$	$\beta_1$
<b>H2a</b>	Time (T) has a direct relationship with efficiency	2.181	0.485
<b>H2b</b>	Resources (R) has a direct relationship with efficiency	1.470	0.679
<b>H2c</b>	Communication (C) has a direct relationship with efficiency	2.127	0.511

Similar to Hypothesis 1b, the results suggest that the trainees believed that both the trainer and tools play an important role in training efficiency. The training was efficient when the material provided was easy to follow and well explained by the trainer. Additionally, training was efficient when the trainer was consistent and when trainer presentations included exercises for the trainees to complete. The relationship between communication and efficiency was also seen as important. The impact of communication implies trainers should give clear explanations throughout the training and that managers and trainers trainees should communicate objectives and expectation to trainees before training. Time had a direct relationship to efficiency as well. This result implies that time must be managed properly throughout the training session in order for training to be efficient.

### *5.1.3 Discussion of Hypotheses H3a and H3b*

Hypothesis 3a and 3b, respectively, state that efficiency and effectiveness is impacted by time, resources, and communication, as summarized in Table 5-3. Although communication was seen to have a direct relationship with effectiveness and efficiency, it was eliminated from multiple regression models. Factors that may have contributed to the elimination of communication from the final model included the high Pearson correlation coefficients and variance inflation factor value, as well as the low Cronbach's alpha value for communication. The models for effectiveness and efficiency suggest that resources have the largest impact (based on the value of the slope coefficients) for both models. In particular, the value of the slope coefficient is over two times greater for resources in the effectiveness model and just under two times in the model for efficiency.

Table 5-3 Research Hypotheses with Coefficients for Multiple Regression Models

	<b>Hypotheses</b>	$\beta_0$	$\beta_1^*$	$B_2^{**}$
<b>H3a</b>	Time, resources, and communication impact effectiveness	-0.935	0.387	0.907
<b>H3b</b>	Time, resources, and communication impact efficiency	1.124	0.274	0.508

\*Time Coefficient, \*\*Resources Coefficient

The results from both the linear and multiple regression models support the importance of resources on both training effectiveness and efficiency. This suggests that the trainer should focus on evaluating their contribution in assisting trainees during training, as well as the impact of training materials, tools used to assist throughout the session, and any additional material used. In addition, the time allotted during training and time spent during training for explanation and practicing should be carefully evaluated and modified to best meet the training session's learning outcomes.

#### *5.1.4 Compare and Contrast with Findings from Field Study*

This section compares the findings from the analysis of the quantitative models to the top ten findings which emerged from the onsite interviews and literature review. This comparative analysis is summarized in Table 5-4.

Table 5-4 Comparison of Findings from Regression Analyses and Findings from Interviews (Bold indicates evaluation aspects identified in both the literature search and the field study.)

<b>Top ten evaluation aspects identified from field study</b>	<b>H1a</b>	<b>H1b</b>	<b>H1c</b>	<b>H2a</b>	<b>H2b</b>	<b>H2c</b>	<b>H3a</b>	<b>H3b</b>
<b>Satisfaction with the training session schedule</b>	X			X			X	X
Application to trainee's daily duties and responsibilities		X			X		X	X
<b>Comfort level of trainees in communicating with supervisor about training session</b>			X		X			
Knowledge of content area prior to training session			X			X		
<b>Level of engagement</b>			X			X		
<b>Whether or not training was voluntary or mandatory</b>			X			X		
<b>Appropriateness of teaching aids</b>		X			X		X	X
Effectiveness of teaching aids		X			X		X	X
<b>Ease of working with other group members during the training session</b>			X			X		
<b>Quality of relationship between trainer and trainee</b>			X			X		
<b>Appropriateness of training facility</b>		X			X		X	X
Level of buy-in from trainees		X			X			
Amount of time during training that does not provide value to trainee	X				X		X	X

The field study focused on all training delivered to personnel before continuous improvement training was deployed. All evaluation aspects identified in the field study were also supported by findings from the quantitative study. An emergent theme from the interviews was the importance of communication. While this variable did not stay in the final multiple regression models, a direct relationship between communication and both effectiveness and efficiency was found. Resources were perceived as having a substantial impact as identified by employees during

interviews. This relationship was also obvious after the continuous improvement training had been delivered based on the regression model results. The influence of time was very obvious from the interview results. Time did appear to have an important role in both effectiveness and efficiency based on the final regression models.

## 5.2 Discussion

The section explores the limitations of the study and identifies area for future research. The chapter concludes with a summary of the implications resulting from this study.

### 5.2.1 *Study Limitations*

Five limitations were identified that may have limited the researcher's ability to establish reliable conclusions in regards to the relationships between the independent and dependent variables studied. The first limitation to this study was the time and resources available to evaluate the training. The limited amount of time that elapsed between training and the distribution of the second survey did not allow the research to observe whether or not outcomes were sustained, i.e., utilization of resources and continued communication. The limited resources prevented researchers from collecting data specific to organizational or financial aspects of the training. This limitation kept the focus of the research on variables that were observed only by trainees.

The second limitation was that this research was conducted in a single manufacturing organization. This limitation makes it difficult to distinguish between factors that may be unique to this organization unseen factors that may be important to a broader cross section of manufacturing organizations. Similar to a case study conducted by Liker & Morgan (2011, p 25),

“It would be unreasonable to attempt to generalize from a single case on the one best way to transform an organization to lean product development.”

The third limitation of this study was the number of participants. There were only 29 respondents, and only two of the respondents indicated that they were shop floor employees. Feedback from front line personnel could provide a different perspective of the factors influencing the continuous improvement training effectiveness and efficiency. Since shop floor employees are often the target audience, this is an important perspective (Jorgensen & Kofoed, 2007).

The fourth limitation was the small number of variables included in this study. The variation observed in the dependent variables might be explained by other input or process factors that were not included in this research. Additional demographic variables might also better explain the variation observed, e.g., age, union status and number of years employed by organization.

The fifth limitation was the small number of survey items for the variable of communication. The limited number of survey items made it difficult to accurately capture communication before, during, and after training. The survey created included seven items specific to the variable of communication. Three of the survey items were focused on communication before training, one item was focused on communication during training, and three items were focused on communication after training. The broad range of communication survey items made it so consistency in responses to survey items was low, which is confirmed with a low Cronbach's alpha value for the variable of communication.

### *5.2.2 Future Work*

As a result of this study, opportunities for future research have been identified. First, one extension to this research is a study that includes additional evaluation criteria focused on determining whether or not outcomes are sustained, i.e., utilization of resources and continued communication. Second, the research could be expanded to include organizational-level and focused measures of training effectiveness and efficiency. Third, future research should include multiple organizations to help distinguish between variables that may be unique to a particular organization culture and those that are important across a wide variety of organizations. Fourth, future research variables focused on capturing primarily front-line employees input would be valuable. Lastly, future research should collect additional demographic information, that might provide additional explanatory power. In particular, data related to the age, union status, number of years employed by organization could be potentially influential and should be included in future studies. Fifth, future adaptations of the surveys can include at least five survey items targeted towards understanding communication before training, five survey items targeted towards understanding communication during training, and five survey items targeted towards understanding communication after training.

### *5.2.3 Implications*

The implications of this research to the existing body of knowledge, as well as to practitioners, are discussed next.

#### *5.2.3.1 Implications to the Body of Knowledge*

The findings from this study contribute empirical evidence and an evaluation methodology of training effectiveness and efficiency to the current training literature. The tools and methodology

used for this study can be adapted and used to evaluate other training. The research completed confirms and challenges findings from previous training research. The findings from the research confirm the importance of evaluating the emphasis of time. In addition, the findings contribute empirical evidence on the importance of evaluating resource utilization during and after the training (Tudor, 1994). The research also makes an important contribution by addition to the limited number of previous studies that have evaluated variables related to the efficiency of training.

Finally, this research contributes a unique evaluation process to literature on continuous improvement training. The evaluation completed for this study focused on the effectiveness of training related to the initial phase of an organization embarking on utilizing continuous improvement tools. The majority of the current literature focuses on evaluating the effectiveness of continuous improvement tools after these tools have been both introduced and well established within an organization.

#### *5.2.3.2 Implications for Practitioners*

The methodology and tools presented in this research provide a template that can be used to assist managers and trainers in conducting an assessment prior to initiating training, as well as an evaluation assessment for established CI training. It is critical that trainers are continuously evaluating and improving their training, particularly as organizations adapt continuous improvement tools to be applied throughout an organization. The results of such an evaluation can help organizations grow and become more self-reliant and can also help ensure that their employees' job and interpersonal skills continue to improve (Worthy, 1994).

Findings from this study conclude that trainers should evaluate their performance to ensure that they were efficient with their use of time and that their presentations are helpful to trainees. Similarly, managers should not underestimate the contributing role that they place in assisting employees with the implementation of continuous improvement tools in the work environment.

In addition, findings from this study conclude that trainers should evaluate the training material and presentations used throughout training. Specifically, trainers should evaluate to ensure that training material is easy to follow and consistent with the presentation. Trainers should not under invest in preparing customized training material and presentations.

The findings from this research can assist trainers and managers in gaining a better understanding of the additional complexities that must be accounted for when designing continuous improvement training programs to fit a particular organizational current culture. Managers must understand the importance of creating a successful continuous improvement training programs in creating an environment in which CI tools can be successfully applied throughout an organization. Ultimately, the findings of this study emphasize the value and need for trainers and managers to pay attention to improving and adapting training just as they must to other key business processes.

“Training directors must keep up with the current literature on training methods because previous successes or failures can help shape the selection or design of a training program. It is equally important to determine a means of evaluating the program before it is implemented” (Muchinsky, 1997, p. 180)

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## Appendix A: Interview Guide for Executives/Supervisors

## INTERVIEW GUIDE FOR EXECUTIVES/SUPERVISORS

Name: \_\_\_\_\_ Company: \_\_\_\_\_

Position: \_\_\_\_\_

Interviewer(s): \_\_\_\_\_

Date: \_\_\_\_\_ Start time: \_\_\_\_\_ End time: \_\_\_\_\_

## Introductory Comments

In this interview, we are interested in understanding your role and experiences in training the employees of your company in the areas of problem solving and process improvement. We are benchmarking a variety of organizations in an effort identify what successes and challenges your organization has experienced. We are also interested in documenting training practices and tools that might be applicable to XXXXXXXXXX

<b>Roles and Current Training Details</b>	
1. How long have you worked in your current position?	
2. What efforts have your organization been involved in that are related to training employees in problem solving and/or process improvement?	
3. When did training first begin?	
4. Have you participated in the development or	

<p>deployment of these programs training?</p> <p>5. Why did your organization decide to complete this type of training within your organization? Do you have specific goals established to determine the success of this training? If so, what are your goals?</p> <p>6. What kind of process control and/or problem solving tools do you use? (A3, RCA, Cause-effect diagram, control charts, Pareto chart, etc.)</p> <p>7. Who participates in using these tools?</p> <p>8. What resources are available for supporting this training? (Budget? Staff? Facilitation? Training?)</p> <p>9. Have you obtained any additional resources to sustain this training? How much and from who?</p> <p>10. How many executives and supervisors are actively involved in this training? How do you evaluate the training program's performance? What objective/measurable results have you achieved?</p>	
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<p>What types of non-measurable benefits have you realized?</p>	
<p><b>Measurement</b></p>	
<p>11. Does your company have a quality policy and/or system?</p> <p>12. What ISO certification does your company have?</p> <p>13. What ISO certification is your company working toward?</p> <p>14. Have certain aspects of your efforts been more or less successful than others? Is so, why do you think this was so?</p> <p>15. Overall, how would you assess the results of this training?</p> <p>16. What factors had the greatest impact on outcomes, both positive and negative?</p> <ul style="list-style-type: none"> <li>• Resource availability and constraints</li> <li>• Level of shop floor employee engagement</li> <li>• Extent of senior-level company support</li> <li>• Company incentives/disincentives</li> </ul>	

<b>Future</b>	
<p>17. Has the way your company approaches training changed as a result of this work? Please explain.</p>	
<p>18. Has the relationship between your company and the customer changed as a result of this work? Please explain.</p>	
<p>19. What do you consider the key lessons learned?</p> <ul style="list-style-type: none"><li>• About training design</li><li>• About training implementation</li><li>• About required steps for each process</li><li>• About program sustainability</li></ul>	
<p>20. Are you aware of any replication of the work by other companies? Has your company assisted any other companies with replication?</p>	
<p>21. Are there any additional documents that you can provide and what information do they contain? We are particularly interested in:</p> <ul style="list-style-type: none"><li>• Training coursework/material</li><li>• Data to show the impact of this training</li><li>• Reference material/documentation</li></ul>	

## Appendix B: Interview Guide for Front-line Personnel

## INTERVIEW GUIDE FOR SHOP FLOOR EMPLOYEES

Name: \_\_\_\_\_ Company: \_\_\_\_\_

Interviewer(s): \_\_\_\_\_

Date: \_\_\_\_\_ Start time: \_\_\_\_\_ End time: \_\_\_\_\_

## Introductory Comments

In this interview, we are interested in understanding your opinions about training that has helped you be able to problem solve and improve the manufacturing processes you are responsible for in your company.

<b>Probes</b>	
1. What tools do you to help you improve your process?	
2. If so, how frequently, are they helpful, etc?	
3. Describe your training experiences in the company, with regards to problem solving and process improvement	
4. What do you like best about the training?	
5. What do you like least about the training?	
6. What changes in the process did you notice in your work as a result of the training	

<p>you received?</p> <p>7. What changes in documentation did you notice in your work as a result of the training you received?</p> <p>8. How would you change the training to better meet your needs?</p> <p>9. Were you able to suggest and implement changes to your process or work-area you felt necessary after the training?</p> <p>10. Was there follow-up after the training to reassess any changes made?</p> <p>11. What were your expectations about this training?</p> <p>12. Have your expectations been met?</p> <p>13. What recommendation would you offer to other organizations who would like to improve their processes?</p>	
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## Appendix C: Recruitment Materials

**These instructions will be used to recruit participants from the training class. The text will be read to participants of the classes (with the permission of the trainer).**

Your help is needed for an important research study. Lindsay Wiseman, a master's student working on her thesis in the School of Mechanical, Industrial and Manufacturing Engineering, is working on a research project involving evaluating continuous improvement training. This study will attempt to analyze the connection between the effectiveness and efficiency of training to the quantity and quality of time, resources, and communication used throughout the continuous improvement training process. This study is co-sponsored by [REDACTED]

Your participation is requested to help explore the impact of these variables and analyze their connection to the effectiveness and efficiency of the training event. We are looking for volunteers who have completed a continuous improvement training activity to complete two short surveys regarding their training experience. The surveys will take approximately 5-10 minutes each to complete. Survey A looks at evaluating the training session you just participated in. Survey B looks at the impact of the same training evaluated using Survey A in your work area after at least two weeks have passed. If you choose to participate you are asked to not provide your name, so your participation will be anonymous. There will be no communication to [REDACTED] about your decision to participate.

**These instructions will be read to all participants after the copies of the survey have been distributed.**

Remember that participation is completely voluntary. There will be no penalty if you choose not to participate. Do not include your name or any other identifier on the survey. We ask that you identify your occupational specialty (as you see best fits), the type of continuous improvement training, and any category of previous continuous improvement training you have received while at [REDACTED]. You may choose not to rate some of the items if you wish. If you have any questions at any time while completing the survey, please feel free to ask. You may request a copy of these oral instructions and/or the survey itself for your records. Please return Survey A and Survey B to the labeled lock box located next to the main entrance for [REDACTED]. The researcher, Lindsay Wiseman, will be the only one with a key to access the surveys in the lock box.

If you have any questions or comments, you may contact Lindsay Wiseman at WisemanL@onid.orst.edu or Toni Doolen at toni.doolen@oregonstate.edu. If you have any questions about your rights as a research subject, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, OSU Research Office, 541-737-8008, [IRB@oregonstate.edu](mailto:IRB@oregonstate.edu).

Please begin by reading the letter on the front page.

[Participants begin taking the survey.]

## Appendix D: Survey Cover Letter



Dear Employee of [REDACTED],

Your help is needed for an important research study. Lindsay Wiseman, a master's student working on her thesis in the School of Mechanical, Industrial and Manufacturing Engineering, is working on a research project involving evaluating continuous improvement training. This study will attempt to analyze the connection between the effectiveness and efficiency of training to the quantity and quality of time, resources, and communication used throughout the continuous improvement training process. This study is co-sponsored by [REDACTED] and [REDACTED].

We are looking for volunteers who have completed a continuous improvement training activity to complete two short surveys regarding their training experience. Each survey will take approximately 5-10 minutes to complete. Survey A looks at evaluating the training session you just participated in. Survey B looks at the impact of the same training evaluated using Survey A in your work area after at least two weeks have passed. If you choose to participate, you are asked to not provide your name, so your participation will be anonymous. You may choose not to participate or answer any of the questions. There will be no employment impact with [REDACTED] in regards to your choice to participate.

If you wish to participate, please respond to the questions starting on the next page. Do not include your name or any other identifier on the survey. We ask that you please identify your general job title (as you see best fit), the type of continuous improvement training which you most recently received, and any other continuous improvement training you have received while at [REDACTED]. Please return Survey A and Survey B to the labeled lock box located next to the main entrance for [REDACTED]. The researcher, Lindsay Wiseman, will be the only one with a key to access the surveys in the lock box.

If you have any questions or comments, you may contact Lindsay Wiseman at WisemanL@onid.orst.edu or Toni Doolen at toni.doolen@oregonstate.edu. If you have any questions about your rights as a research subject, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, OSU Research Office, 541-737-8008, [IRB@oregonstate.edu](mailto:IRB@oregonstate.edu)

Please detach this cover letter from the survey and keep it for your records.

Appendix E: Survey A

**Survey A**

Please fill in the blank

The following questions will not be used for identification purposes. All responses are voluntary.

Occupational speciality at Cascade Steel Rolling Mill:  Shop Floor  Manager  Other (please specify): \_\_\_\_\_

Most current training (evaluated using this survey):  A3 Report  5S  Root Cause Analysis  Other: \_\_\_\_\_

Previous CI training (other than training being evaluated):  A3 Report  5S  Root Cause Analysis  Other: \_\_\_\_\_

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1 I knew what to expect out of the training before I arrived	1	2	3	4	5
2 I expect to positively impact my work area as a result of what I learned in this training	1	2	3	4	5
3 Sufficient time was provided to explain each topic	1	2	3	4	5
4 The presentation was consistent with the handouts	1	2	3	4	5
5 I am confident I can communicate with my immediate supervisor or about the material that was covered during the training	1	2	3	4	5
6 Time was well spent thorough the entire training session	1	2	3	4	5
7 I plan to use the tools I learned in training in my work environment	1	2	3	4	5
8 I will be able to use the tools taught in this training in my work environment	1	2	3	4	5
9 The training session was well organized	1	2	3	4	5
10 I understood the objectives of the training from the beginning	1	2	3	4	5
11 The training material was easy to follow	1	2	3	4	5
12 The trainer was able to keep the training session within the allotted time frame	1	2	3	4	5
13 I had all the tools on hand I needed to help me understand the material	1	2	3	4	5
14 The trainer gave clear explanations	1	2	3	4	5
15 The trainer was prepared	1	2	3	4	5
16 The tools taught in this training will help improve the performance of my work area	1	2	3	4	5
17 I was able to complete all exercises	1	2	3	4	5
18 I was able to work with my peers to better understand the material taught in this training	1	2	3	4	5

**\*\*\*\*\* PLEASE TURN OVER TO COMPLETE\*\*\*\*\***

## Appendix E: Survey A (continued)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
19 The training material was consistent	1	2	3	4	5
20 I found the learning tools used during this training helpful	1	2	3	4	5
21 I was informed about my participation in this training event prior to the day of the training	1	2	3	4	5
22 Sufficient time was allowed from training	1	2	3	4	5
23 The trainer was organized	1	2	3	4	5
24 The presentation of the material helped me complete the exercises	1	2	3	4	5
25 Sufficient time was allocated to practice each tool	1	2	3	4	5
26 I was able to ask my instructor questions to get a better understanding of the training material	1	2	3	4	5

**Survey B**

Please fill in the blank

The following questions will not be used for identification purposes. All responses are voluntary.

Occupational specialty at Cascade Steel Rolling Mill:  Shop Floor  Manager  Other (please specify): \_\_\_\_\_

Most current training (evaluated using this survey):  A3 Report  5S  Root Cause Analysis  Other: \_\_\_\_\_

Previous CI training (other than training being evaluated):  A3 Report  5S  Root Cause Analysis  Other: \_\_\_\_\_

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1 I have shared a copy of the training material with co-workers who have not yet participated in similar training	1	2	3	4	5
2 I have recommended co-workers to go through similar training	1	2	3	4	5
3 I have been able to use the tools taught in this training in my work environment	1	2	3	4	5
4 The tools taught in this training have helped improve the performance of my work area	1	2	3	4	5
5 I have used the tools I learned in training in my work environment	1	2	3	4	5
6 I have been able to communicate with my immediate supervisor about the material that was covered during the training	1	2	3	4	5
7 I have been able to contact the trainer since the training event	1	2	3	4	5
8 I have referred back to a copy of the training material	1	2	3	4	5
9 I have noticed a positive impact in my work area as a result of what I learned in this training	1	2	3	4	5

# Continuous Improvement Training



Toni L. Doolen, PhD  
Lindsay Wiseman



## Course Topics

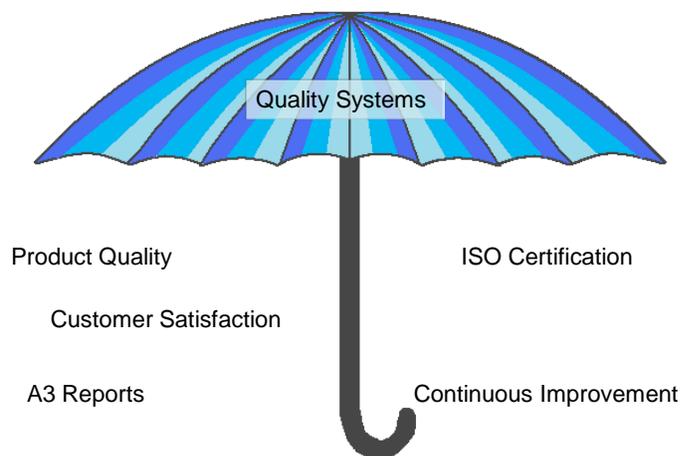
Session	Overview
1	<ul style="list-style-type: none"> <li>•Introduction and Objectives</li> <li>•A3 report</li> <li>•Background information</li> <li>•Current condition</li> </ul>
2	<ul style="list-style-type: none"> <li>•Cause Analysis</li> <li>•Measurement</li> <li>•Target Condition Identification</li> </ul>
3	<ul style="list-style-type: none"> <li>•Target Condition Selection</li> <li>•Implementation Plan</li> <li>•Follow-up plan</li> </ul>

## Getting Started

- ▶ Introductions
- ▶ Objectives
  - Communicate process improvement activities using an A3 report.
    - Identify a problem in your area.
    - Analyze the problem.
    - Determine and implement solutions for the problem.
    - Measure improvement.
    - Identify additional changes.



## Where Continuous Improvement fits?



## What is an A3 Report

- ▶ Toyota Motor Corporation developed a structured problem-solving approach, which was summarized on a single piece of paper.
- ▶ The term "A3" refers to the paper size used for the report (11" x 17").
- ▶ The report records the investigation, planning, and results of a problem solving or continuous improvement activity on a single sheet of paper.



## A3 Report Template

<b>Problem:</b> 	Department: _____ Date: _____ Project Leader: _____ Project Team: _____																																
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## Purpose of an A3 Report

- ▶ Document and manage CI activities
  - Document the planning, decisions, and learning involved with solving a problem.
  - Provide a structured problem solving process
- ▶ Facilitate communication
  - Develop a common language for talking about Continuous Improvement (CI).



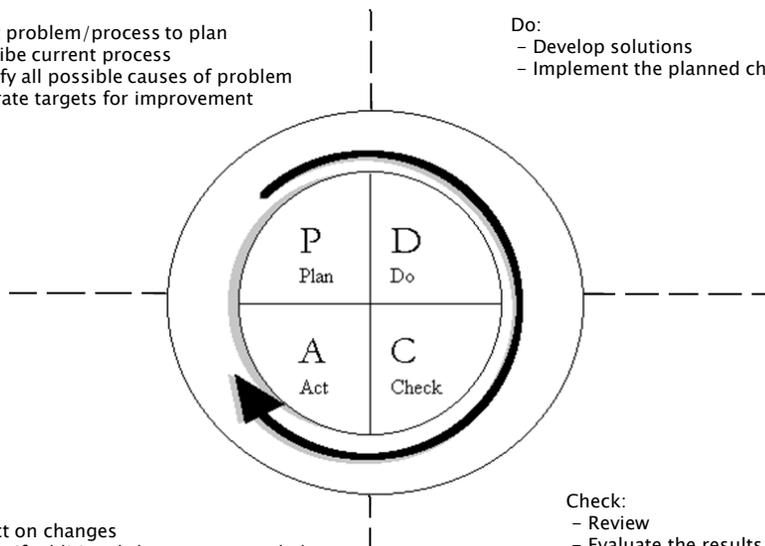
## Continuous Improvement (CI) and PDCA

### Plan:

- Select problem/process to plan
- Describe current process
- Identify all possible causes of problem
- Generate targets for improvement

### Do:

- Develop solutions
- Implement the planned changes



### Act:

- Reflect on changes
- Decide if additional changes are needed

### Check:

- Review
- Evaluate the results

# PDCA and CI Tools

Plan	Tools
Select the problem/process to be addressed	Brainstorming, Affinity Diagrams
Describe the current process	Process Diagram
Identify all possible causes of problem	Pareto Charts, 5 Whys, Fishbone Diagrams
Generate targets for improvement	Brainstorming
Do	
Develop solutions	Brainstorming, Decision matrices
Implement the plan	Process measurement
Check/Confirm	
Review and evaluate the results of changes	Before-and-After Pareto Charts, GAP Analysis
Act	
Reflect on changes and decide if additional changes are required	Performance measurement and review

## A3 Report Template

**Problem:** "What is the focus?"

- Identify process area for improvement
- Brainstorm list of problems and select target problem

Department: \_\_\_\_\_

Date: \_\_\_\_\_

Project Leader: \_\_\_\_\_

Project Team: \_\_\_\_\_

---

**Background:** Problem details

- Context required for full understanding
- Importance of the problem

**Implementation Plan**

What?	Who?	When?	Progress
Action to be taken	Responsible person(s)	Time and Date	
			⊕
			⊕
			⊕
			⊕
			⊕
			⊕

---

**Current Condition:**

- Diagram current situation (or process)
- Highlight problem specifics with storm bursts
- Measure extent of problem

---

**Cause Analysis**

- List problem
- Get down to the root cause
  - 5 Whys
  - Fishbone diagram
  - Pareto chart

---

**Target Condition**

- Diagram of proposed new process
- Key performance measures

**Follow-up**

Reasons for missing target	Results Tracking			
Action items for the next review	Date	Target	Actual	Gap
	Notes about results			

Gap = difference between target and actual

# A3 Report & CI

Plan

<p><b>Problem:</b></p> <hr/> <p><b>Background:</b></p> <hr/> <p><b>Current Condition:</b></p> <hr/> <p><b>Cause Analysis</b></p> <hr/> <p><b>Target Condition</b></p> <hr/>	<p>Department: _____</p> <p>Date: _____</p> <p>Project Leader: _____</p> <p>Project Team: _____</p> <hr/> <p><b>Implementation Plan</b></p> <table border="1"> <thead> <tr> <th>What?</th> <th>Who?</th> <th>When?</th> <th>Progress</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td>⊕</td></tr> </tbody> </table> <hr/> <p><b>Follow-up</b></p> <table border="1"> <thead> <tr> <th rowspan="2">Reasons for missing target</th> <th colspan="4">Results Tracking</th> </tr> <tr> <th>Date</th> <th>Target</th> <th>Actual</th> <th>Gap</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table> <p>Gap = difference between target and actual</p>	What?	Who?	When?	Progress				⊕				⊕				⊕				⊕				⊕				⊕				⊕				⊕	Reasons for missing target	Results Tracking				Date	Target	Actual	Gap																				
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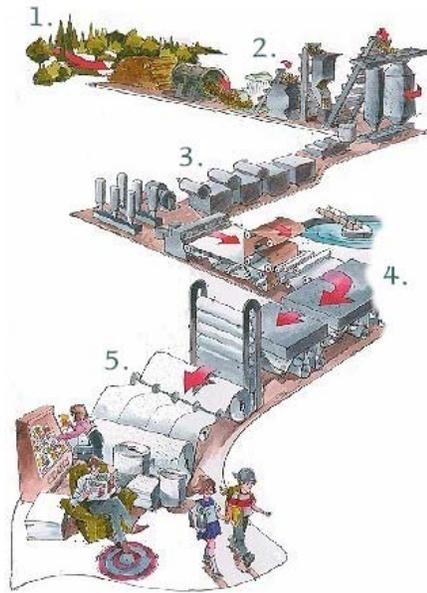
# Problem Statement

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# Process

## Definition:

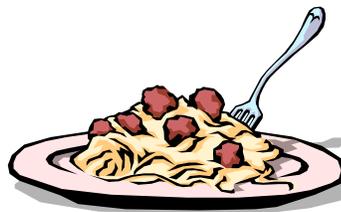
A process is a set of related activities that are based on a set of inputs and result in outputs that have added value. A process is how work is done.



## A Simple Process Example

### Making spaghetti

- What are the activities involved?
- What are some inputs?
- What are the outputs?



# Brainstorming

Definition: A method for a team to creatively and efficiently generate a lot of ideas.

## Steps for Brainstorming

1. Write down topic or question for everyone to see.
2. Individually write down ideas on sticky notes.
3. Gather all ideas in one location.
4. Review the ideas.
5. Ask questions to clarify.
6. Discard duplicates.



## Brainstorming Practice

1. In groups of 2–3, identify a process that needs improvement in your work area or a problem that need to be corrected.
2. Brainstorm at least 10 possible sub-ideas.
3. Write each idea on a sticky note.

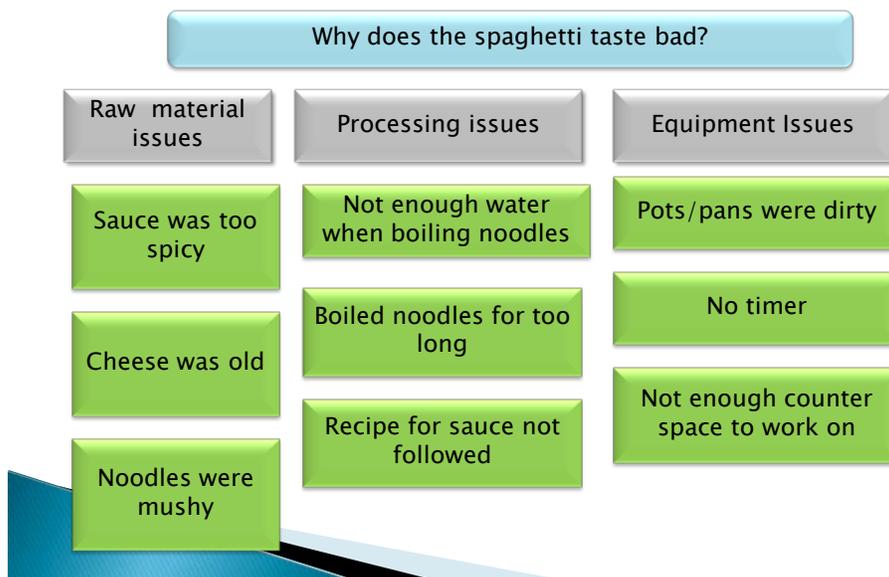


## Affinity Diagrams

- ▶ Definition: Tool designed to help organize ideas generated during brainstorming.



### Affinity Diagram Example



## Selecting the Problem

- ▶ The problem statement on your A3 report should identify the problem and process that you will be focused on fixing and improving.

**Example:** Stop 'N Go Pizza is a small but growing pizza delivery business with six shops. After a period of rapid growth, Stop 'N Go Pizza experienced a six-month decline in orders.

Problem: Customers orders are declining.



## A3 Problem Development Practice

- ▶ Based on your brainstorming and affinity diagram, select five possible issues relevant to your work area that could be the target of a continuous improvement activity.

- 1.
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_



## Background of A3 Report

<b>Problem: "What is the focus?"</b> <ul style="list-style-type: none"> <li>Identify process area for improvement</li> <li>Brainstorm list of problems and select target problem</li> </ul>	Department: _____ Date: _____ Project Leader: _____ Project Team: _____																																				
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## Background

- ▶ The background section includes information necessary to describe the problem more fully. The background section also clarifies why the problem is important to the organization. Indicate why solving the problem is important.

## Background Example

**Example:** Top management of Stop 'N Go Pizza looked at the weekly sales reports, the number of new employees, and information collected from customer surveys. They found that:

- Customers were complaining about pizzas being delivered cold and/or later than they were originally told
  - The busiest time for delivering was on Friday and Saturday nights.
  - There were a high number of new employees delivering the pizza who were unfamiliar with the area.
  - The sales had decreased significantly over the last two months.
- 

## Collect Background Information

- ▶ Identify stakeholders who could help understand the selected problem.
    - Stakeholder = an employee, group, department, etc. who would be impacted by changes to a process.
  - ▶ Create a list of specific questions and information to get from each stakeholder.
    - Who?, What?, When?, Where?, Why?, How?
- 

## Background Practice

- ▶ Answer the following questions using the information provided in the case study:
  - How do the problems that Loaf'n Around is experiencing impact the company?
  - Who are the stakeholders who would help clarify the issue?
  - What questions and information would the process owner need from each of these different stakeholders?



## Current Condition

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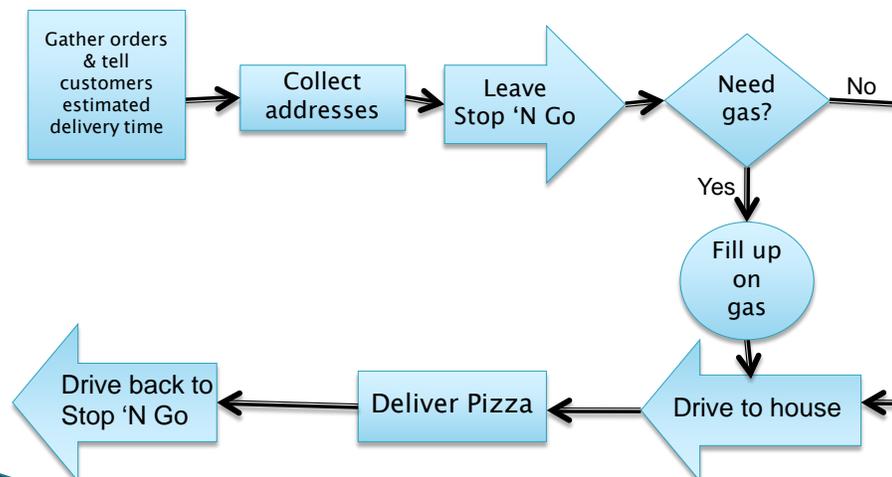


## Document Current Condition

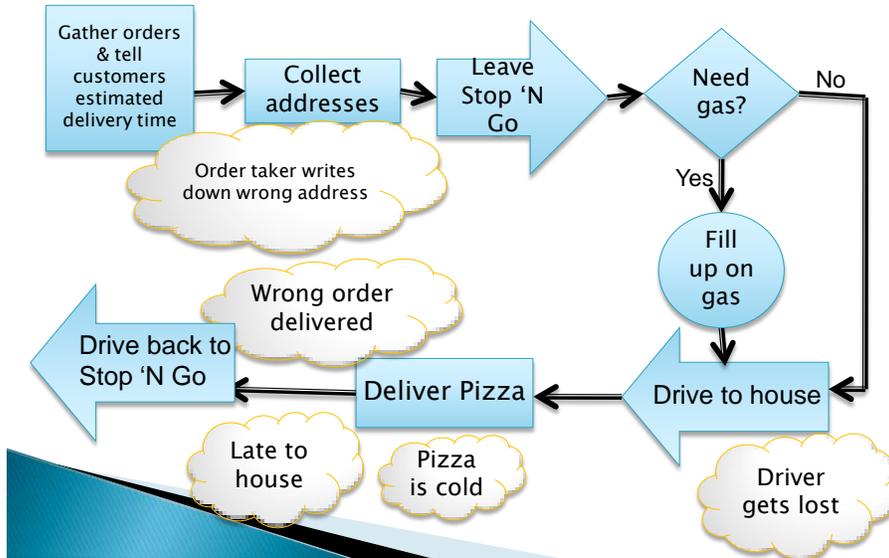
- ▶ Create a diagram that illustrates how the current process works.
  - Hand-drawn diagrams (in pencil) are easy to create and change.
- ▶ Label the diagram so that anyone knowledgeable about the process can understand the diagram.
- ▶ Note issues on the process diagram.
- ▶ Include measurements related to the problem wherever possible.



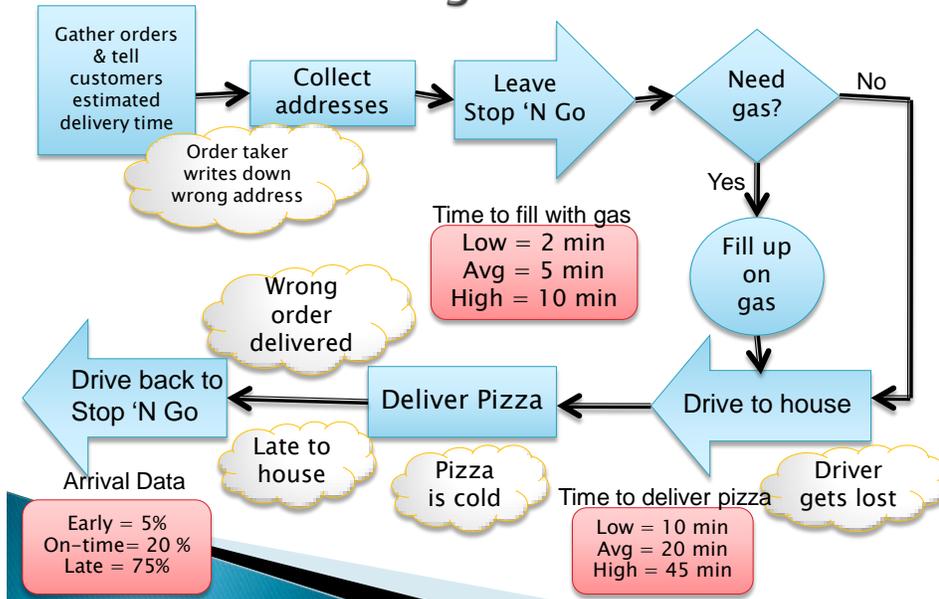
## Process for Delivering Stop 'N Go Pizza



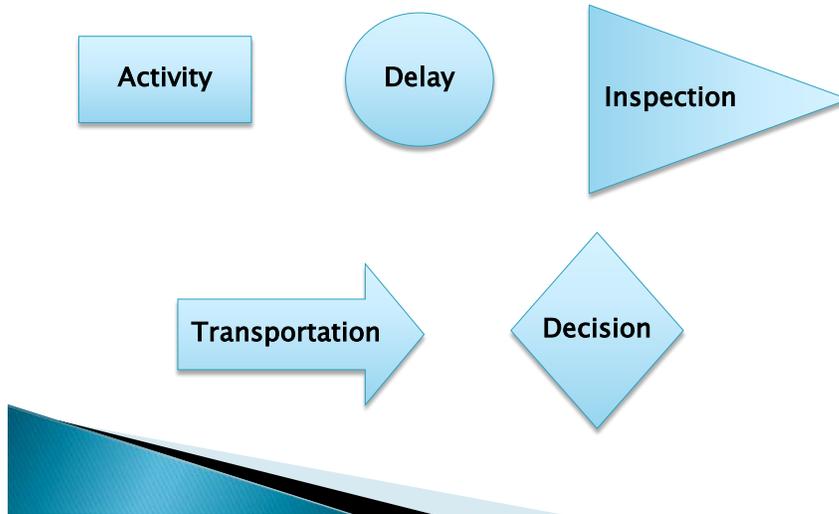
## Process flow diagram cont'd - 1



## Process flow diagram cont'd - 2



## Process Diagram Symbols

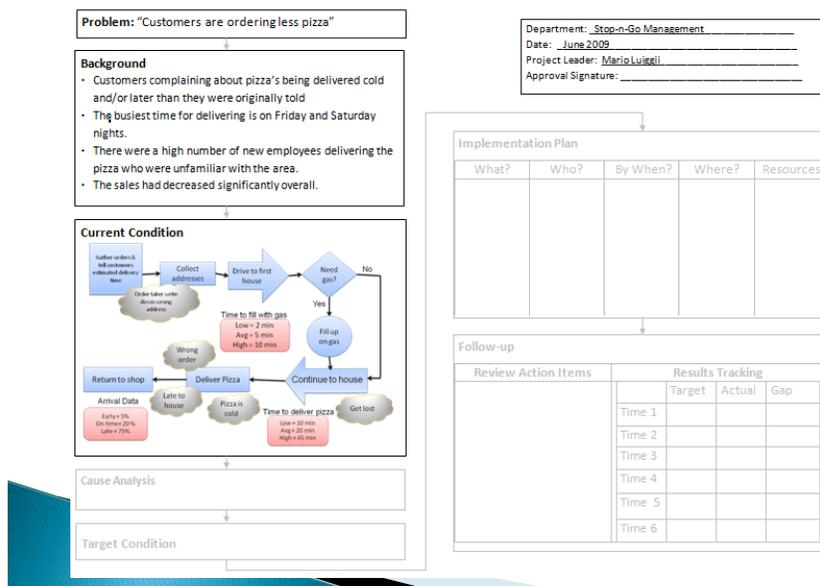


## Current Condition Practice

- ▶ Create a process diagram for Loaf'n Around.
  - Use the process diagram symbols
  - Include “storm bursts” for process issues that may be related to the problem.
  - Include measurements that help quantify the problem



## A3 Diagram for Stop-n-Go Pizza



## Homework Assignment #1

1. Identify a problem that you will use for your continuous improvement activity.
2. Gain a deeper understanding of the problem by discussing the problem with at least two different stakeholders.
3. Collect background information.
4. Document your chosen problem, background information, and the current condition (use a process diagram) on an A3 Report.
5. Bring the A3 Report to the next class.

## Debrief of homework #1

- ▶ Share with the class
  - Problem statement
  - Key background information
  - Process diagram



## Course Topics

Session	Overview
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# A3 Report Template

**Problem:**

**Background:**

**Current Condition:**

**Cause Analysis**

**Target Condition**

Do

Department: \_\_\_\_\_

Date: \_\_\_\_\_

Project Leader: \_\_\_\_\_

Project Team: \_\_\_\_\_

**Implementation Plan**

What?	Who?	When?	Progress
			🕒
			🕒
			🕒
			🕒
			🕒
			🕒
			🕒
			🕒

**Follow-up**

Reasons for missing target	Results Tracking			
	Date	Target	Actual	Gap

Gap = difference between target and actual

# Cause Analysis

**Problem:** "What is the focus?"

- Identify process area for improvement
- Brainstorm list of problems and select target problem

**Background:** Problem details

- Context required for full understanding
- Importance of the problem

**Current Condition:**

- Diagram current situation (or process)
- Highlight problem specifics with storm bursts
- Measure extent of problem

**Cause Analysis**

- List problems
- Get down to the root cause
  - 5 Whys
  - Fishbone diagram
  - Pareto chart

**Target Condition**

- Diagram of proposed new process
- Key performance measures

Department: \_\_\_\_\_

Date: \_\_\_\_\_

Project Leader: \_\_\_\_\_

Project Team: \_\_\_\_\_

**Implementation Plan**

What?	Who?	When?	Progress
Action to be taken	Responsible person(s)	Time and Date	🕒
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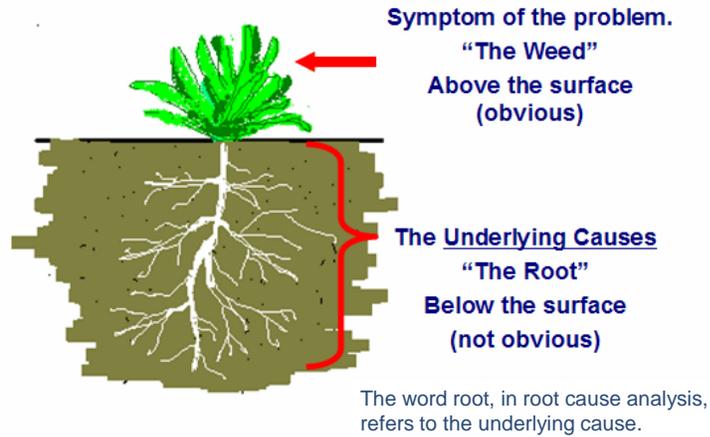
**Follow-up**

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	Date	Target	Actual	Gap

- Action items for the next review
- Notes about results

Gap = difference between target and actual

## Root Cause Analysis



## Tools for Root Cause Analysis

- ▶ 5 whys
- ▶ Fishbone Diagrams
- ▶ Pareto Charts
- ▶ Etc.

# A3 Report for Top-N-Go Pizza

<b>Problem:</b> "Customers are ordering less pizza" <b>Background:</b> <ul style="list-style-type: none"> <li>Customers complaining about pizza's being delivered cold and/or later than they were originally told</li> <li>The busiest time for delivering is on Friday and Saturday nights.</li> <li>There were a high number of new employees delivering the pizza who were unfamiliar with the area.</li> <li>The sales had decreased significantly overall.</li> </ul>	Department: <u>Stop-n-Go Management</u> Date: <u>September 2009</u> Project Leader: <u>Mario Luiggi</u> Project Team: <u>John Class, Jenny Crevling, Sarah Martinez, Andrew Walling</u>																																												
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## 5 Why's

- ▶ List the main problem(s)
- ▶ Ask "why?" until you reach a specific, identifiable root cause. You haven't reached the root cause until you've asked "why?" at least 5 times!
- ▶ List the answers to each why question

### Problem

- ↳ first immediate cause
  - ↳ cause for the first immediate cause
    - ↳ deeper cause to the preceding cause
      - ↳ etc.

## 5 Whys example 1

### Example:

Problem: Customers are ordering less pizza

Why? – Customers are dissatisfied that deliveries are late, especially on Friday and Saturday nights.

Why? – Drivers get lost

Why? – Given wrong directions

Why? – Order takers are rushed

Why? – The order taker is answering two phone-lines at once.



## 5 Whys example 2

### Example:

Problem: Customers are ordering less pizza

Why? – Customers are dissatisfied that deliveries are late, especially on Friday and Saturday nights

Why? – Drivers get lost

Why? – Don't know the area well enough

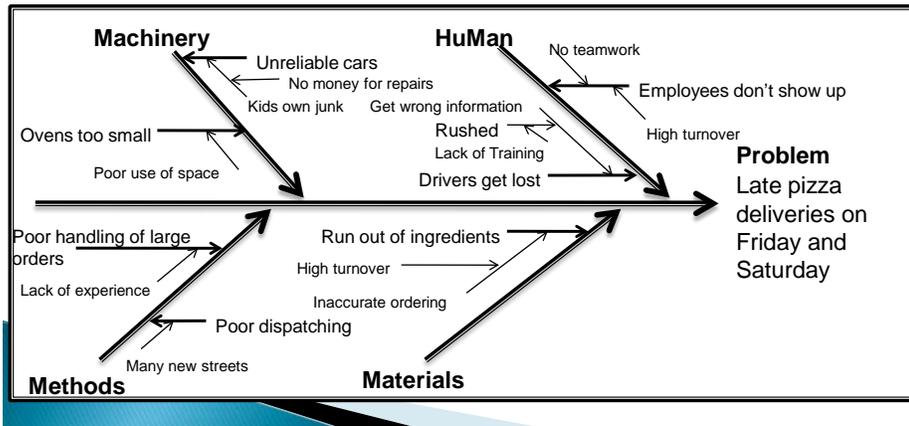
Why? – Lack of training

Why? – High turn-over rate of employees

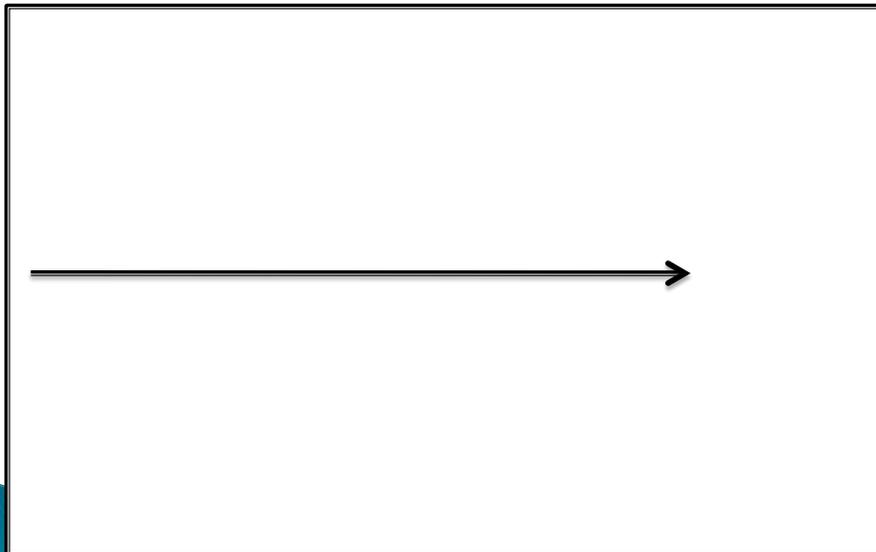


## Fishbone Diagrams

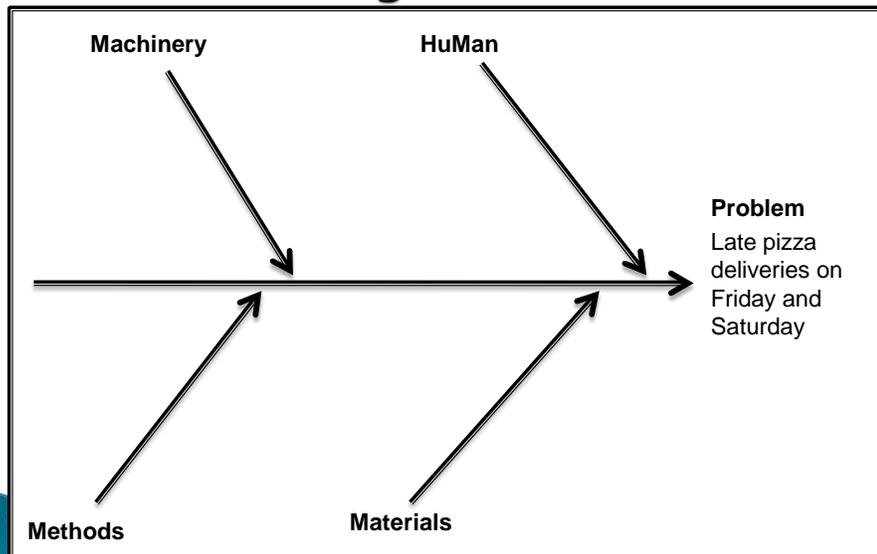
- ▶ The diagram looks like a fish skeleton, with a main idea forming the backbone and connecting ideas forming the smaller bones.



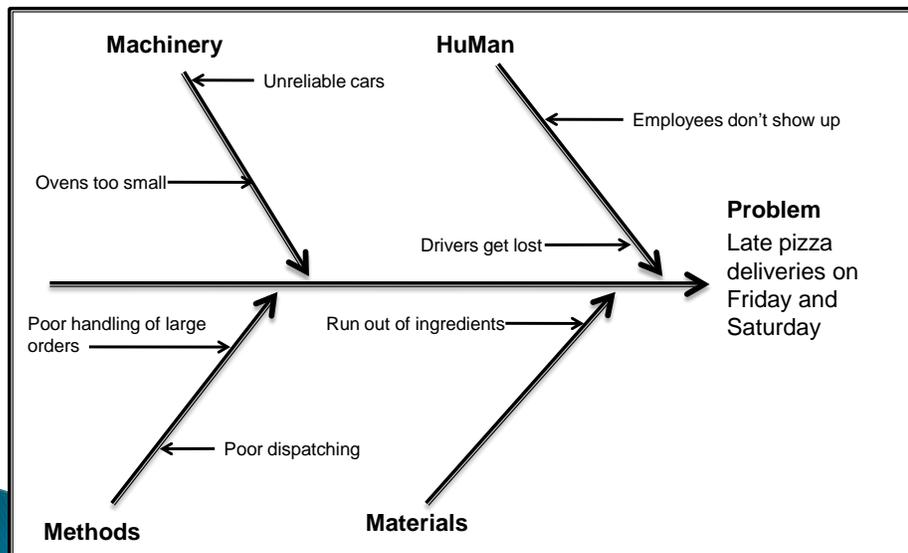
## Fishbone Diagram Problem



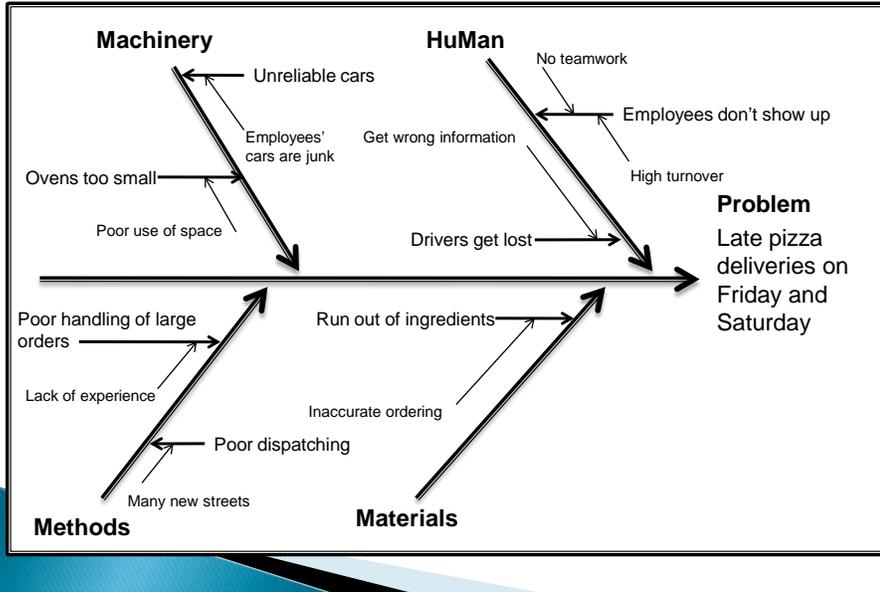
## Fishbone Diagram Outline



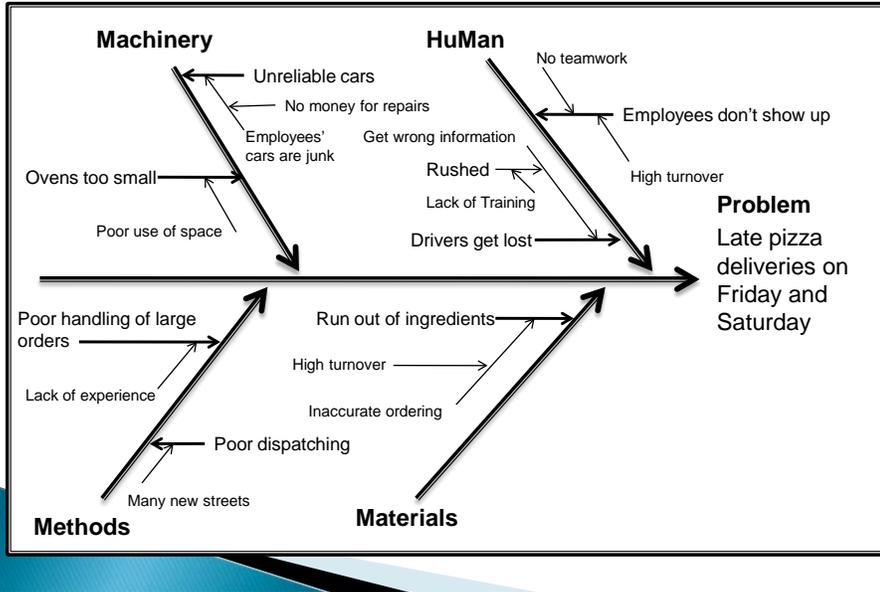
## First Level Causes



## Second Level Causes

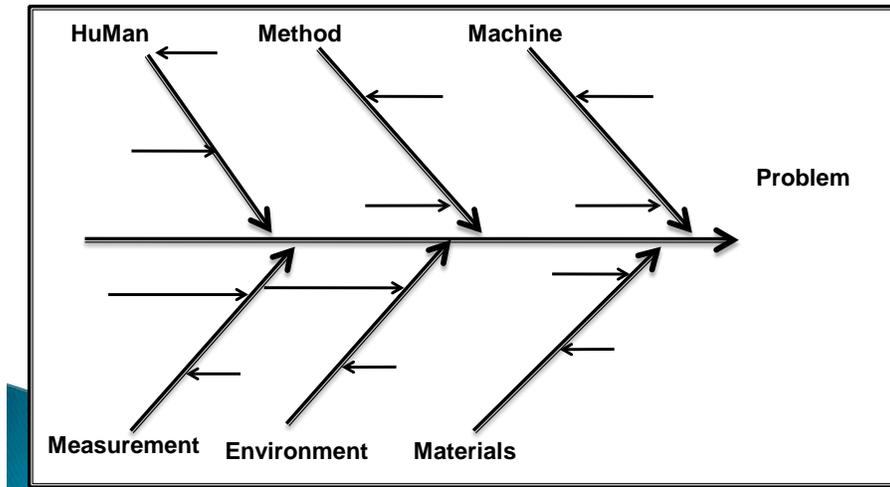


## Third and Fourth Level Causes



## Fishbone Practice

- ▶ Create a Fishbone Diagram for Loaf'n Around.



## Pareto Charts

- ▶ Definition: A bar graph that displays categories of items based on the number of their occurrences.
- ▶ Questions the Pareto chart answers:
  - What are the largest issues facing our team or business?
  - What 20% of sources are causing 80% of the problems?
  - Where should we focus our efforts to achieve the greatest improvements?



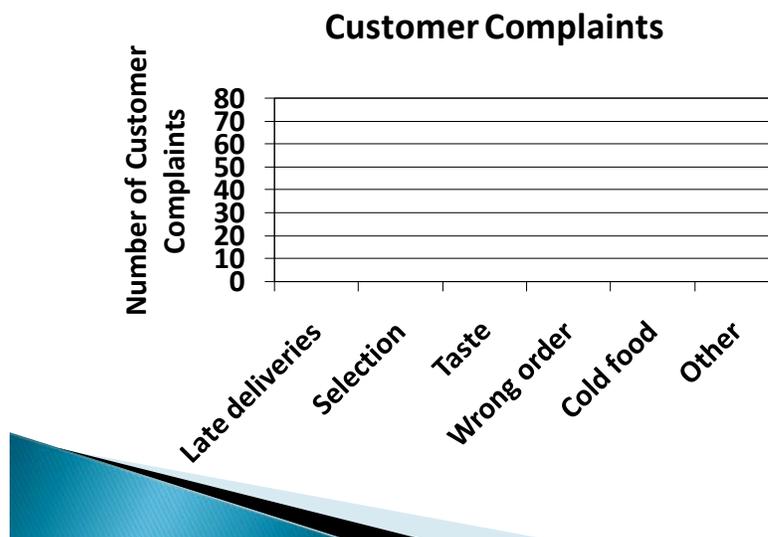
## Pareto Chart (1)

- ▶ Question to answer:
  - Why aren't the customers satisfied?
- ▶ Collect data

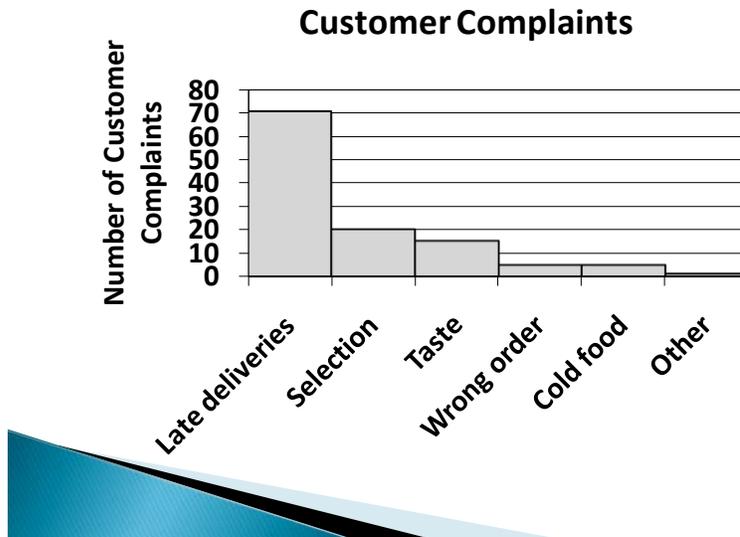
	Late Deliveries	Too Little Selection	Taste	Received Wrong Order	Pizza was Cold	Other
Quantity	70	20	15	5	5	1



## Pareto Chart (2)



## Pareto Chart (3)



## Pareto Chart Uses

- ▶ Identify most common causes for a problem
- ▶ Select a starting point for process improvements.
- ▶ Clarify the extent to which specific causes contribute to a problem.
- ▶ Monitor the progress of improvement activities.

## Pareto Chart Practice

- ▶ Using the information for Loaf'n Around to create a Pareto chart.
  - Include
    - Units used for measurements on the y axis
    - A title



## Measurements

- ▶ Definition: Numerical data which provide insight or feedback on the performance of a process.
- ▶ Examples
  - Billets between cobbles
  - % failed (inspection results)
  - % downtime



## Need for Measurement

"You can't control what you don't measure".

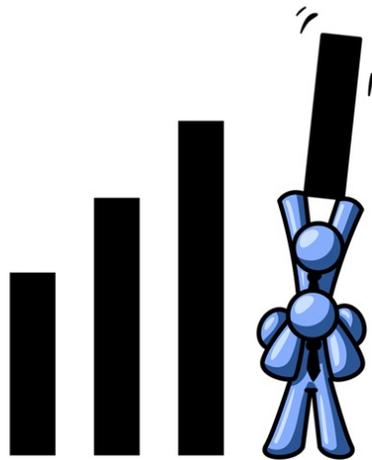
(Deming, W.E. Out of the Crisis.  
Cambridge, MA: MIT, 1986. )

Without measurement there is no way to know how a process is performing; therefore there is no way to improve it.



## Process Measurement Areas

- ▶ Safety
  - Burn accidents/month
  - First aids/month
- ▶ Quality
  - % of tests failed
  - % Compliance
- ▶ Productivity
  - Tons melted/hr
  - Billets rolled/hr



## Target Condition

Do

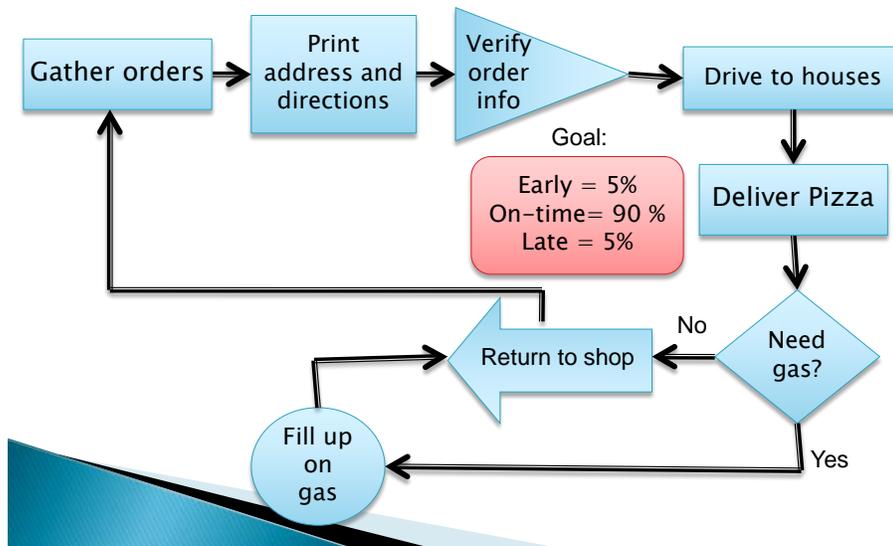
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## Target Condition Identification

- ▶ Insert a diagram that illustrates how the proposed, improved process will work.
- ▶ Include the changes that will address the root cause(s) identified.
- ▶ Predict the expected performance level (descriptively and numerically)



## Target Condition Example



## Target Condition Practice

- ▶ Create a target condition process diagram for Loaf'n Around.
- ▶ Link changes made to the causes identified in the fishbone diagram and Pareto chart.

## Homework Assignment #2

1. Collect data and create a Pareto chart and fishbone diagram for your chosen problem.
2. Complete at least two 5 why's activities to identify potential root causes.
3. Add the results of the analyses to A3 Report from Homework Assignment #1.
4. Sketch three possible target conditions (do not include on A3 report yet).
5. Decide which alternatives your group would like to focus on. Why did you choose this alternative?
6. Bring updated A3 Report to the next class.



## Debrief of homework #2

- ▶ Share with the class
  - What you learned from using the analysis tools
  - One alternative target condition
- ▶ What difficulties did you encounter in completing this homework?



# Course Topics

Session	Overview
1	<ul style="list-style-type: none"> <li>•Introduction and Objectives</li> <li>•A3 report</li> <li>•Background information</li> <li>•Current condition</li> </ul>
2	<ul style="list-style-type: none"> <li>•Cause Analysis</li> <li>•Measurement</li> <li>•Target Condition Identification</li> </ul>
3	<ul style="list-style-type: none"> <li>•Target Condition Selection</li> <li>•Implementation Plan</li> <li>•Follow-up plan</li> </ul>

## Target Condition

**Problem:** "What is the focus?"

- Identify process area for improvement
- Brainstorm list of problems and select target problem

Department: \_\_\_\_\_

Date: \_\_\_\_\_

Project Leader: \_\_\_\_\_

Project Team: \_\_\_\_\_



**Background:** Problem details

- Context required for full understanding
- Importance of the problem

**Implementation Plan**

What?	Who?	When?	Progress
Action to be taken	Responsible person(s)	Time and Date	⊕
			⊕
			⊕
			⊕
			⊕
			⊕
			⊕

**Current Condition:**

- Diagram current situation (or process)
- Highlight problem specifics with storm bursts
- Measure extent of problem

**Follow-up**

Reasons for missing target	Results Tracking			
	Date	Target	Actual	Gap
• Action items for the next review				
• Notes about results				

Gap = difference between target and actual

**Cause Analysis**

- List problems
- Get down to the root cause
  - 5 Whys
  - Fishbone diagram
  - Pareto chart

**Target Condition**

- Diagram of proposed new process
- Key performance measures

## Target Condition Selection

- ▶ A team may find it helpful to use a numerical tool to compare target condition alternatives.



## Decision Matrix

- ▶ Definition: A tool to compare different alternatives through the user of selection criteria and weighting.



## Decision Matrix

- ▶ Good to use when you have to decide between multiple options
- ▶ Steps:
  - List all possible alternatives
  - List criteria for making a decision
  - Rate each criteria on an importance scale, e.g. 1–10 where 10 is the most important



## Decision Matrix Example (1)

- ▶ Identifying a hotel to stay at for a family vacation
- ▶ Sum of criteria is the best possible score

	Good Location	Swimming Pool	Affordable	Kid Friendly	Sum
Criteria rating	7	4	10	8	29
Motel 6					
Marriott Suites					
Hilton					
Kids Bunks					



## Decision Matrix Example (2)

- ▶ Score each alternative with a -1, 0, or 1 for each criteria
  - -1 = does not meet criteria
  - 0 = neutral
  - 1 = does meet the criteria

	Good Location	Swimming Pool	Affordable	Kid Friendly	Sum
Criteria rating	7	4	10	8	29
Motel 6	-1	-1	1	-1	
Marriott Suites	1	1	0	0	
Hilton	1	-1	-1	-1	
Kids Bunks	0	1	1	1	

## Decision Matrix Example (3)

- ▶ Calculate the scores for each hotel
  - Multiply the rating by the importance for each criteria
  - Add up the scores for each alternative
    - Hotel 6 =  $(-1*7) + (-1*4) + (1*10) + (-1*8) = -9$
  - Select alternative with highest (most positive) total sum

	Good Location	Swimming Pool	Affordable	Kid Friendly	Sum
Criteria rating	7	4	10	8	29
Motel 6	-1	-1	1	-1	-9
Marriott Suites	1	1	0	0	11
Hilton	1	-1	-1	-1	-15
<b>Kids Bunks</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>22</b>

## Decision Matrix Practice

- ▶ List your three alternative target conditions.
- ▶ Identify at least 4 criteria that your group believes are important.
- ▶ Rate each criteria with a number between 1 and 10.
- ▶ Score each alternative (-1, 0, 1)
- ▶ Calculate the overall sum for each alternative.
- ▶ What alternative did you choose?
- ▶ Is this different than what you decided previously?

## Implementation and Follow-up

<b>Problem:</b> <hr/> <b>Background:</b> <hr/> <b>Current Condition:</b> <hr/> <b>Cause Analysis</b> <hr/> <b>Target Condition</b> <hr/>	Department: _____ Date: _____ Project Leader: _____ Project Team: _____ <div style="text-align: right; font-size: small;">  </div>																																																
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# A3 Report with Implementation Plan

**Problem: "What is the focus?"**

- Identify process area for improvement
- Brainstorm list of problems and select target problem

---

**Background: Problem details**

- Context required for full understanding
- Importance of the problem

---

**Current Condition:**

- Diagram current situation (or process)
- Highlight problem specifics with storm bursts
- Measure extent of problem

---

**Cause Analysis**

- List problems
- Get down to the root cause
  - 5 Whys
  - Fishbone diagram
  - Pareto chart

---

**Target Condition**

- Diagram of proposed new process
- Key performance measures

Department: \_\_\_\_\_

Date: \_\_\_\_\_

Project Leader: \_\_\_\_\_

Project Team: \_\_\_\_\_

Implementation Plan			
What?	Who?	When?	Progress
Action to be taken	Responsible person(s)	Time and Date	
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			(0/100)
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} Act

**Follow-up**

Reasons for missing target

- Action items for the next review
- Notes about results

	Results Tracking		
	Date	Target	Actual

Gap = difference between target and actual

## Implementation Plan

- ▶ List the actions which must be completed to get to the Target Condition
- ▶ List the individual responsible for the action and a due date. Who? What? Where? When?
- ▶ Add other information, such as cost and resources needed, which is relevant to the implementation.

Implementation Plan			
What?	Who?	When?	Progress
Action to be taken	Responsible person(s)	Time and Date	
			(0/100)
			(0/100)
			(0/100)
			(0/100)

# A3 Report Follow-up Plan

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## Follow-up Plan

- ▶ Set measurable goals for performance (targets)

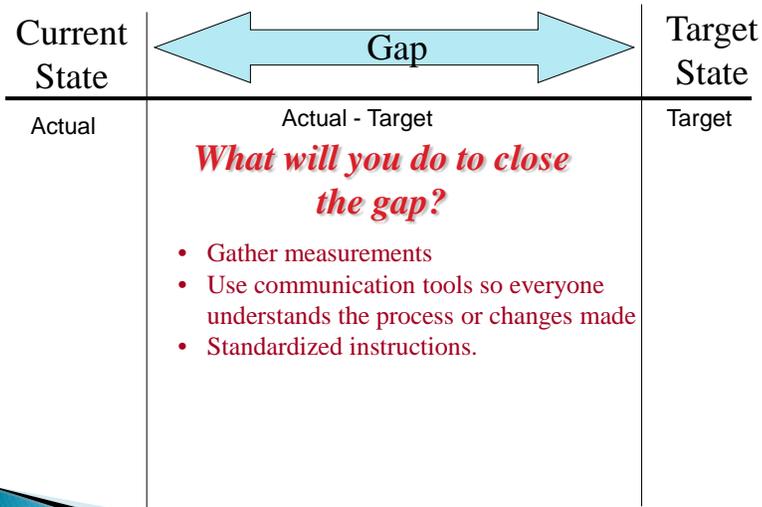
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Gap = difference between target and actual				

## Gap Analysis – Checking

- ▶ How far are you away from your performance target.
- ▶  $\text{Gap} = (\text{Current performance}) - (\text{target performance})$
- ▶ Use tools to visually display gaps:
  - Trend chart
  - Pareto chart



## Closing the Gap



## Practice Closing the Gap

- ▶ Use the information in Loaf'n Around to develop ideas for closing the gap
  - Use previous activities to fill in the 'current state' and 'target state' of the table.



## Homework Assignment #3

1. Establish performance goals/targets for your process
2. List possible actions for closing the gap.
3. Incorporate this information onto the follow-up section of the A3 report
4. Get approval to go ahead and implement changes in your areas.

