Assessing the Effectiveness of the Problem Solving Skills of Mold Technicians Who Have Completed the Problem Solving Course at Phillips Plastics Corporation

By

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ABSTRACT

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The results of this research indicate that Mold Technicians at Phillips Plastics Corporation have integrated five of the problem solving tools taught in the company's Problem Solving course into their work routines. The five problem solving tools researched were: brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagrams. These tools were chosen on the basis of their universal popularity and utilization. A survey was distributed to eighty-five Mold Technicians at eight production facilities in three geographical areas: West Central, Medford, and Phillips, Wisconsin. The return rate was 31.8%. Data compiled in this research is from the 27 completed and returned surveys. The results indicated all five of the tools were used, yet at varying frequencies. Brainstorming is the most popular tool and was used by 26 of the 27 respondents. The Mold Technicians also reported that they use the problem solving tools alone and as team members. The tools were used by Mold Technicians on teams to determine the root cause of a problem and to arrive at a solution to the problem. Costs, savings, or benefits were reportedly calculated before implementing a solution, although

no specific examples were supplied by the Mold Technicians. The five problem solving tools are used by a majority of the Mold Technicians on a weekly basis.

Acknowledgements

I would have been unable to complete this research project without the assistance, support, and guidance of the following people. To all, my most heartfelt thank you!

- Chris Ness, fellow Mondovian, for correcting my survey and compiling the data afterwards. I also enjoyed our conversations about the Mondovi sesquicentennial.
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- Hector T. Cruz for reading, correcting, suggesting, and guiding me through the steps of writing a research paper.
- And most importantly, I would not have made it through my first semester of Graduate School much less complete it, without the encouragement, financial support, and love of my wife, Susan M. Schultz.

Dedication

This research paper is dedicated to two friends who have passed away. Both were excellent problem solvers, and more importantly, true friends whom I will remember for the rest of my life.

When we met in June 1979, Richard Meyer was the Maintenance Department Supervisor at Teel Plastics in Baraboo, Wisconsin. We became coworkers and hunting partners shortly after. Richard passed away quietly in December 1990 as a blizzard dumped over three feet of snow outside. How ironic that he had snowshoes for so many snowless years. Without fail, his name comes up every November as we sit around the wood stove at Moose Kamp. Maybe we need someone to reload the wood stove. Maybe another cribbage player is required. Someone in charge of dish washing is always nice. "Camp boy" Richard did all of this with genuine joy. He loved to be in camp. Completing camp chores was how he relaxed. He seldom went into the woods. Richard and I served together on many problem solving teams. Several of our projects are still in use at Teel Plastics. The ask why five times example in Chapter Two was Richard's project.

I met Otto Alwin three weeks after Richard. He was Teel's night shift supervisor and was later promoted to first shift supervisor. He passed away in August 2004 one day after returning from a Canadian fishing trip. Otto was a sportsman's sportsman. He was a fisherman, hunter, archer, golfer, and team organizer for softball, volleyball, and even broom hockey. Otto got Teel Plastics people involved anyway he could think of. Despite poor vision, he was the most accurate archer I've ever known. It was only after I left Teel that Otto and I finally spent a day together. After years of inviting me to all sorts of events, we finally spent a February day ice fishing at Devil's Lake in Baraboo. Like

Richard, we never took our poles out of the truck. The day was spent with friends sitting around a wood stove in a fish shanty.

Otto and I spent years together on the Cores R Us and other quality teams. He was great at “thinking out of the box.” For example, when we were brainstorming ways to decrease the length variation on a tube, Otto’s idea was to hire blind quality inspectors! Otto’s creations will forever be in use at Teel Plastics.

Both of these men lived life like they were dying. I could live a healthy life and reach two hundred years of age, yet never experience or know the freedom and spirit that drove Richard and Otto. To Richard and Otto, I raise my stein and promise that I will practice the skills you’ve taught me in problem solving and life.

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Chapter I: Introduction

The ability to identify and accurately solve problems in a timely manner is considered an important workplace skill worldwide (Workplace Essential Skills, 2000; The Australian Education Council and Ministers of Vocational Education, Employment, and Training, 1992). In the United States, numerous government agencies, industries, and professional and educational associations recognize problem- solving skills as essential (Gale, Wojan, & Olmsted, 2002). The United States Department of Labor Bureau of Labor Statistics lists problem solving as an important skill for employees in over 30 job classifications. The job range is immense and includes dancers and choreographers, trucking and warehousing, physicists and astronomers, mechanics, and top executives (Occupational Outlook Handbook, 2002-2003).

The Appleton, Wisconsin Police Department has a problem solving model and form posted on the Internet. The form guides an officer attempting to resolve domestic abuse cases (problem solving model). Problem solving instruction is offered to businesses in many ways. A quick web search displayed a seemingly endless list of providers. A recent study found that problem solving skills growth exceeded that of math and reading for employees in the telecommunications industries (Gale, Wojan, & Olmsted, 2002). Problem solving assistance is also available to improve personal relationships. Coping.org offers free Internet instruction in various subjects, including problem solving (Messina & Messina, 2004). The shrinking world requires Wisconsin companies to make sure employees are good problem solvers.

Phillips Plastics is a Wisconsin corporation that stresses training, including problem solving skills. The company started injection molding plastic parts at a creamery in Phillips, Wisconsin in 1964. A new plant was built in 1967 and a second facility opened in Medford, Wisconsin in 1973. This facility provided design, manufacturing, decorating, and assembly of injection molded parts. In order to maintain growth as a leader in the injection molding industry, additional facilities with special missions were added. Today, Hudson, Eau Claire, Menomonie, Prescott, and New Richmond, Wisconsin all house one or more Phillips Plastics buildings. The responsibilities of the 2,000-person workforce are wide ranging. Tasks include research, automation, process improvements, engineering, design, development, sales, and other services required for manufacturing.

Parts are manufactured for a diverse group of worldwide customers in the automotive, medical, communication, and other industries. Most of the $216 million sales come from injection molded plastic products. An eye to the future has lead to the creation of two metal molding facilities as well. Metal injection molding and magnesium injection molding are in the infancy stage compared to plastic injection molding. Phillips Plastics is one of a handful of American molders willing to provide the resources required to enter this specialty field (Corporate overview, culture, history, 2004).

Bob Cervenka is one of two founders and is Chairman of the Board. He coined the phrase "All people are important." This is reflected in the company's culture. Phillips Plastics grew, in part, by creating a people-oriented atmosphere that provided training for employment and personal growth. Phillips' full time instructors conduct a 12-hour problem solving course several times each year (Phillips Plastics Problem Solving Process, 1992). The Phillips employees who operate and control the throughput of the molding machines are called Mold Technicians or Mold Techs, or more commonly, simply Techs. They are directly responsible for the quantity and quality of the parts. One of Phillips Plastic's commitments is to meet or exceed industry standards in quality and delivery. A qualified Mold Technician understands the press, process, auxiliary machinery, resin, and tools inside and out. It takes many years of experience to be an effective Mold Technician. Finding qualified Mold Technicians to support growth is a difficult task. There are few schools offering this training. The economy does not allow five years of trial and error using on-the-job training (OJT).

Phillips Plastics created the Mold Technician Development Program in 1992. The purpose is to provide technical training throughout the company (Mold Technician Development Program Handbook, 2002). There are at least 26 courses and over 470 hours of classroom training. Promotions are based on completion of specified groups of classes. Admittance in the Mold Technician Development Program is competitive because the wage potential for Mold Technicians is higher than other production jobs. Managers, engineers, supervisors, and other employees seeking advancement opportunities may also enroll in the classes, but Mold Technicians typically have priority.

A publication of the Wisconsin Department of Workforce Development guides the reader through a six step problem solving model (Problem Solving, 1998). The six steps are: identify the problem, assess available resources, set objectives, plan development, implement the plan, and evaluate the results. The problem solving process is at times condensed for simplicity or expanded for greater detail. The typical problem solving model contains five sequential steps (Bransford & Stein, 1984; Gick, 1986; Hayes, 1988). The five steps (in order) include: identify the problem, represent the problem (graphs, etc.), select an appropriate strategy, implement the strategy, and evaluating solutions (Bruning, Schraw, & Ronning, 1999). The Phillips Plastics process has four steps: analyze, develop, implement, and evaluate. After evaluation, if the problem is not corrected, the process starts over beginning at analyze (Phillips Plastics Problem Solving Process, 1992).

The ability to solve problems effectively is a skill needed by employees worldwide. Workers from entry-level positions through top management in a diverse group of job classifications use these skills on a regular basis. Phillips Plastics, with facilities throughout Wisconsin, recognizes the importance of problem solving for its employees. Mold Technicians are essential in production and must complete the in-house problem solving course. In-house instructors developed the course and four step model to meet specific needs of the company.

Statement of the Problem

Education is an important part of the corporate philosophy at Phillips Plastics. The company's growth and life is credited to the skills and strength of its people. This culture opens the door to education and training. Employees are paid wages, reimbursed for transportation and lodging expenses, and often fed during in-house training. The cost of educating a workforce of 2,000 people is significant. The company website states 3 to 4% of the annual payroll is invested on training or development. Employees complete a written survey after finishing the Phillips Plastics Problem Solving Process course. The survey solicits the student's immediate input, yet there is no documented evidence of actual use of the techniques to solve production problems. This study will examine the utilization of five problem solving tools by Mold Technicians who have completed Phillips Plastics Corporation's 12-hour Problem Solving Course.

Statement of the Purpose

The purpose of the study is to determine if the Mold Technician Development Program participants find the problem solving process a valuable tool in their jobs. Cost savings as a result of the course may be cited as examples. Data will be compiled from surveys of Mold Technicians who have completed the Problem Solving course. This study will analyze and determine to what extent Mold Technicians report using five problem solving strategies taught at Phillips Plastics Corporation.

Research Questions

There are three research questions this study will attempt to answer. They are:

1. How do Mold Technicians use the problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagramming as taught in the Phillips Plastics Problem Solving Process course.
2. Are there significant improvements in productivity and cost/benefit as a result of using the problem solving techniques taught in the Phillips Plastics Problem Solving course? If so, what are they?
3. How is the problem solving process integrated into the Mold Technicians work routine?

Significance of the Study

Follow up research of training is minimal. The Manager of Training and Development at Phillips Plastics will be able to use this format as a model when measuring the effectiveness of other courses in the Mold Technician Development Program. Using the data from this research will save many hours of labor and greatly reduce the cost of course analysis.

A major task in any corporation is developing the annual budget. This study does not concentrate on cost justification, yet measuring effectiveness requires a monetary examination. The Manager of Training and Development could use information gathered in this report to aid budgeting areas such as course modifications, instructor training, or curriculum changes.

Managers want to know the cost benefit ratio of the activities in their departments. Training is scrutinized because Mold Technicians are away from their work stations for periods of a few hours to several days. Scheduling replacements is difficult and productivity may suffer. This study will hopefully explore benefits or provide data to make decisions.

The Training Department at Phillips Plastics will also be able use the information gathered to make decisions. Identifying strengths and weaknesses of the course from a different perspective will provide fresh feedback. The in-house trainers could use this information to implement changes as needed in this or other courses.

The supervisors could use the results to encourage more success or address less productive practices. Supervisors often bear the brunt of work created when Mold Technicians are not on the production floor due to training. Identifying positive or negative results may encourage additional or continued training leading to productivity gains.

Others may also benefit from the study. The time and effort spent will increase knowledge of the problem solving process. A better understanding of the process may improve training methods by providing realistic examples and activities when teaching problem solving or other subjects.

Limitations

Time will be a limitation in this study. Mold Technicians are employed at several facilities in Wisconsin and work different shifts. A diverse group of Mold Technicians from several production facilities will provide data. Every effort will be made to ensure that each Mold Technician is given ample or equal time during data collection.

The use of human subjects is a limitation. It is assumed the Mold Technicians in the study will provide accurate information. The information may come from documented examples or it may be purely an opinion of the Mold Technician that day.

Measurement tools and surveys will be of the author's design and have no documented measures of validity or reliability.

The results of the study should be used with other related documents when making critical or financial decisions. This is warranted by the limitations listed above.

Definition of Terms

People in the plastics industry use terms in conversation and text that may not be familiar to those outside of the industry. Phillips Plastics molds metal as well as plastic and has additional jargon specific to each process. Several of these terms are explained below.

Auxiliary Machines: Any machine that performs complimentary functions of the press such as a temperature controller, automatic inspection machine, or conveyor.

Injection Molding: A manufacturing process that uses heat to soften raw material and force to push it into a mold creating one or more parts. Phillips Plastics injection molds resin (plastic), magnesium, and other metals.

MAG: Phillips Plastics' name for magnesium molding process or facility.

MIM: Phillips Plastics' acronym for Metal Injection Molding. May be used to describe the process or the facility.

Mold Technician: A person who operates the injection molding press and auxiliary equipment. Mold Tech(s) or simply Tech(s) are more frequently used and mean the same.

OJT: Acronym for On the Job Training.

Press: Refers to the machine that heats, transfers, injects, forms, and cools the parts. Short for injection molding machine.

Resin: More commonly referred to as plastic outside of the plastics industry.

Tool: Typically two or more blocks of steel that mate and form a cavity the shape of the part. Raw material is injected and cooled in the cavity during the injection molding process.

Chapter II: Literature Review

This chapter will begin with a discussion of common components and models of problem solving and the tools needed. Section two will examine various methods of teaching problem solving. The last section will review curriculum evaluation methods. The model used by Phillips Plastics Corporation and the problem solving tools, instructional methods, and evaluation techniques will be detailed at the end of each respective section.

Components and Models of Problem Solving and Quality Tools

Problem solving is as old as mankind. Early in the 20th Century, Thorndike conducted experiments on cats in specially designed wooden cartons. The cat was able to escape if it pushed a lever in the crate. He concluded problem solving was mainly by trial and error leading to a solution (as cited in Bruning, Schraw, & Ronning, 1999). About the same time, John Dewey viewed problem solving as a process of five teachable steps. Dewey's model starts with the presentation of a problem, or problem recognition. The second step is defining the problem and identifying the constraints. The third step is developing hypotheses and one or more reasonable solutions. The next step is to test the hypotheses. The most practical solution is determined. The fifth and last step is selecting the best hypothesis based on the strengths and weaknesses of each (as cited in Bruning, Schraw, & Ronning, 1999).

Foreign competition brought problem solving to the forefront of American business and industry in the last three decades. The statement "two heads are better than one" readily applies to problem solving. An individual may use the problem solving techniques discussed in this chapter, yet groups more commonly use them (Roth, Ryder,

& Voehl, 1996). The problem solving methods or models examined in this chapter include The Deming Wheel, an eight step process, DISTIL, IDEAL, DMAIC, and the Phillips Plastics model.

Walter Shewhart was a pioneering statistician at Bell Laboratories in the 1930's. He developed the PDCA problem solving cycle. This is an acronym for Plan, Do, Check, Act. Many models of problem solving used today are modifications of the Shewhart Cycle. The Shewhart Cycle was used so effectively in the 1950s by quality management authority Dr. Edward Deming that it is now referred to as the Deming Wheel. An explanation of each step is listed below (Problem faced to problem solved, 2004).

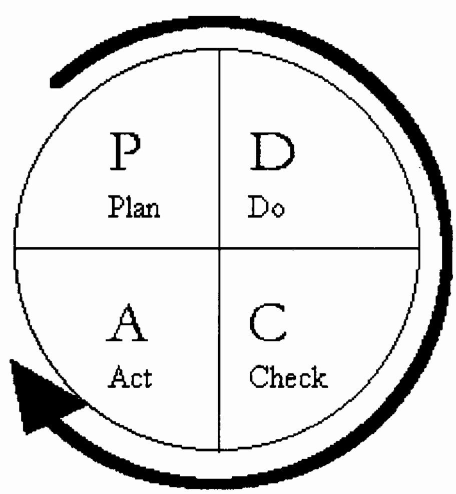

Figure 1. Deming Wheel

1. PLAN to improve by finding what's wrong and create possible solutions. This is accomplished by obtaining data, analyzing the problem, and planning a solution.
2. DO (Do it). Use small scale testing or experimentation on a potential solution. This will minimize disturbances of routine activity.

3. CHECK to determine if the changes made meet the desired result. Measure the change.
4. ACT by modifying as needed and implement the successful changes.

If the results of sampling or experimentation are not satisfactory, go back to the plan stage and identify another possible solution. When the problem is resolved, the cycle is complete. The cycle starts again with a new problem.

An early modification to the cycle came in 1948 at what is now Carnegie Mellon University. The Engineering Department added "Define the Problem" as the first step. This step is still taught today (Six sigma process improvement, 2004).

Properly using the steps in the Deming Wheel, as well as those of the models examined later in this chapter, require knowledge of what are commonly referred to as quality tools. The quality tools are graphic aids, charts, and statistical methods used to collect and analyze data, display the results, and create action plans ("The roadmap to customer impact 6 sigma", n.d.).

Frequently used quality tools include brainstorming, ask why five times, fishbone diagrams, checklists and check sheets, histograms, Pareto diagrams, statistical control charts, measures of central tendency, measures of variability, flow charts, and Gantt charts. The quality tools are sometimes modified by organizations to meet their specific needs. Below is a brief explanation of each.

Brainstorming is probably the best known tool and may be used in several steps of the problem solving process. The goal is to generate a large volume of creative ideas. The rules of brainstorming are:

1. Suspend evaluation or criticism.

2. Be creative, quantity is expected.
3. Freewheeling is encouraged. Offer anything that comes to mind.
4. Build on the ideas already produced.

Participants take turns giving ideas or pass. After everyone passes, the ideas are discussed and pared down to a workable number by group consensus (Roth, Ryder, & Voehl, 1996; Jones & McBride, 1990).

The next tool, "Ask Why Five Times", is used by individuals or groups to determine the real problem instead of the symptoms. The following is a true example of the ask why technique. It took place at a Wisconsin manufacturing plant. An individual was injured after slipping and falling onto a cement floor. The safety committee was asked to investigate. They asked why the person slipped and determined the cause was a result of water on the floor. Asking why again they found water entered through the roof when it rained. They asked why the roof leaked and discovered that fasteners in the metal roof were loose. The committee asked why the fasteners were loose and determined that ice build up lifted the fasteners off the metal roofing creating gaps. Asking why a fifth time revealed the root cause was insufficient drainage on connecting eaves. The roof was repaired and proper drains were installed. The slipping problem was eliminated (R. Meyer, personal communication, 1985).

Fishbone diagrams, or cause and effect analysis, resemble the skeletal structure of a fish. They provide a visual aid and also help pinpoint the root cause instead of symptoms. The problem, or effect, is the head of the fish. The backbone is an arrow pointing towards the head. Major causes are listed as vertical extensions of the backbone. To help stimulate and categorize ideas, these may be defined as the four M's: Machine, Material, Method, and Manpower. Minor causes are entered nearest the major related idea. Ideas are generated using brainstorming and discussed. The top ideas are determined by group consensus (Roth, Ryder, & Voehl, 1996; Moran, Talbot, & Benson, 1990; Jones & McBride, 1990).

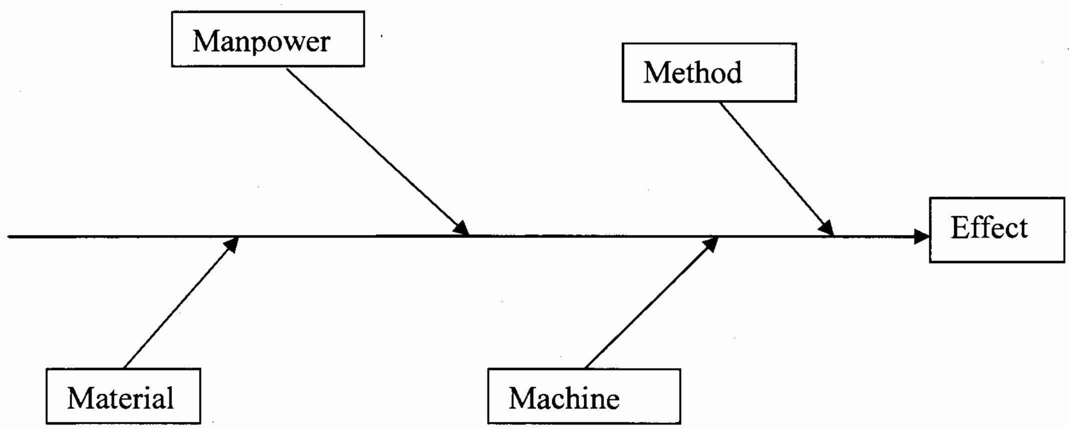

Figure 2. Fishbone Diagram

A checklist is a record that details what is to be completed. A group may develop a checklist as a means of assuring all tasks are accomplished. Manufacturing departments create checklists for machine set up, quality inspections, beginning shift operations, etc. (Roth, Ryder, & Voehl, 1996).

Check sheets are used to collect data or record observations. They are records of how often something happens. Information collected could include reasons for rejecting a part, where the defect was on the part, or other physical specifications. The data is used to construct the statistical information using histograms, Pareto analysis, and similar methods (Roth, Ryder, & Voehl, 1996; Moran, Talbot, & Benson, 1990).

Histograms are used to plot frequency distribution. They are a visual representation of the information recorded on a check sheet or other data sources. The vertical axis represents frequency and the items measured are displayed horizontally (Roth, Ryder, & Voehl, 1996; Moran, Talbot, & Benson, 1990).

Pareto diagrams identify the significance of data using bar graphs. The bars distinguish between the vital few and the trivial many based on the proven Pareto principle that 20% of the sources cause 80% of the problems (Wilson, Dell, &Anderson, 1993; Roth, Ryder, & Voehl, 1996; Moran, Talbot, & Benson, 1990).

Walter Shewhart also developed the statistical control chart to measure process variation. Sometimes called run charts, they identify shifts, trends, and cycles that lead to defects (Roth, Ryder, & Voehl, 1996; Moran, Talbot, & Benson; 1990).

The three measures of central tendency are the mean (arithmetic average), medium (middle value), and mode (most frequent). Sample data collected on a run chart or checklist is transferred to a frequency distribution chart and converted into graphs.

There are three measures of variability: range, variance, and standard deviation. The range is the highest minus the lowest value. The variance and standard deviation are computations used to measure dispersion.

Once calculated, the measures of central tendency and variability can be used to compare against historical data to determine shifts, increases in variability, or a combination of both (Moran, Talbot, & Benson, 1990).

Flow charts list in detail the steps required for a process. Individuals or groups use the steps to identify problems, develop a problem statement, and plan what techniques will be used to solve the problem (Roth, Ryder, & Voehl, 1996).

A Gannt chart is useful for tracking a project. Gannt charts list specific events in relation to a time frame. A matrix is set up listing the events vertically and the dates (days, months, or the time measurement required) spanning horizontally. This provides an easy reference to assigned responsibilities, completion dates, and group accomplishments. Supervisors or other management levels may also keep track of the group using the Gannt chart (Moran, Talbot, & Benson, 1990).

Organizations across the world have also modified the steps in the Deming Wheel to meet their specific goals. The Guide to Graphical Problem-Solving Processes (Moran, Talbot, & Benson, 1989) describes an eight step model. The steps parallel the Deming Wheel and are described in more detail. The eight steps are listed below.

1. Define the problem and identify specific causes to investigate.
2. Collect data in a planned manner.
3. Translate the data into a form usable for analysis.
4. Consolidate and summarize the data using statistical measures and graphics.
5. Analyze the data and make preliminary findings.
6. Communicate the findings.
7. Develop an action plan.
8. Provide a method of monitoring the solution.

Table 1 shows the procedures of the eight step model with examples of commonly used quality tools.

In the book *Problem Solving for Results* (Roth, Ryder, & Voehl, 1996), a ten step model is used that encompasses the Deming wheel in a single step. This model would be used at a corporate level to determine customer needs and implement changes that satisfy customer requirements. The ten steps are condensed into six major groupings that are familiar to typical problem solving models.

Table 1

Eight Step Model

Situation	Process	Tools
Problem Definition	Planning	Diagnostic and screening tools such as brainstorming, fishbone diagrams, Pareto analysis, pie charts, flow charts
Collect/Translate Consolidate Data	Analysis	Statistical and graphical control charts, check sheets, histograms, pie charts and measures of central tendency and variability
Communicate Execute Monitor Data	Action	Narrative, graphical and scheduling tools like histogram, pie, and Pareto charts, flow charts, Gannt charts, control charts

The steps are: the problem, process, cause, numbers, solution, and future. The six steps and quality tools associated with them are shown in table 2.

Table 2

Six Step Model

Step	Quality Tool
The problem	Surveys, charts, data collection
The process	Flow diagrams
The cause	Fishbone diagrams
The numbers	Charts and graphs
The solution	PDCA and selection matrix
The future	Standardize process (run charts)

Solving problems can be a difficult task. Keeping track of the steps and deciding which tools to use and when to use them can be intimidating. Several simplified models have been developed with acronyms to help keep track of the process. The acronyms for three popular problem solving techniques are DMAIC, DISTIL and IDEAL. These also follow the pattern of the PDCA cycle. DMAIC is a model used by highly successful organizations practicing continuous improvement. It's an acronym for define, measure, analyze, improve, and control. DMAIC is a closed loop, systematic, scientific, and factual based process that fits nicely into a problem solving model (The roadmap to customer impact 6 sigma; Pyzdek, 2004).

Tables 3 and 4 clarify DISTIL and IDEAL.

Table 3

DISTIL Model

Step	Tool or Action
Define (the problem)	Brainstorm, choose criteria (cost, success, impact), prioritize
Image	Fishbone diagrams, five Ws, gather data
Selection	Rank and pick most likely cause, pick most likely solution
Test	Experimentation, process control, data collection
Implementation	Action plan (who does what and when), Gannt chart, sell the plan, implement action plan
Longevity	Track after implementation

(Jones & McBride, 1990)

Table 4

IDEAL Model

Step	Tools or Action
Identify the problem	Actively seek problems requiring a solution
Defining problem	Problem representation, obtain a clear picture of the problem
Exploring alternatives	Generation/analysis of alternatives
Acting on a plan	Implementation of ideas
Looking at the effects	Verify results

(Bruning, Schraw, & Ronning, 1999)

The models described above are among the most popular. Many models are available for use to solve problems, yet most can be summarized as a five step model listed below (Bransford & Stein, 1984; Gick, 1986; Hayes, 1988).

1. Identify the problem
2. Represent the problem
3. Select an appropriate strategy
4. Implement the strategy
5. Evaluate solutions

The Phillips Plastics model has four steps. Each step has additional operations that utilize the quality tools. The steps are: Analyze, Develop, Implement, and Evaluate. (See Figure 3.) The following outline details each step.

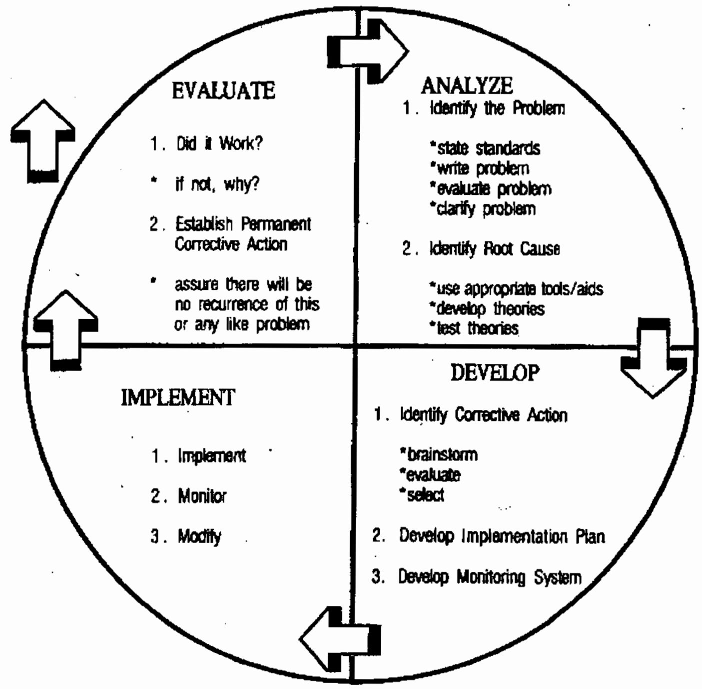

Figure 3. Phillips Plastics Problem Solving Process

Step One: Analyze

1. Identify the problem

- State standards
- Write problem
- Evaluate problem
- Clarify problem

2. Identify root cause

- Use appropriate tools/aids
- Develop theories
- Test theories

Step Two: Develop

1. Identify corrective action
   - Brainstorm
   - Evaluate
   - Select
2. Develop implementation plan
3. Develop monitoring system

Step Three: Implement

1. Implement
2. Monitor
3. Modify

Step Four: Evaluate

1. Did it work?
   - If not, why?
2. Establish permanent corrective action
   - Assure there will be no recurrence of this problem

If the problem persists after completing step four, the process begins again starting at the first step, analyze. The process is complete when the problem is solved and a permanent corrective action is in place.

The quality tools taught in the Phillips Plastics Problem Solving course include brainstorming, flow charting, Pareto analysis, cause and effect or fishbone diagrams, and ask why. A description of each was detailed earlier.

Problem Solving Instructional Methods

Several common instructional methods are used to teach problem solving. The instructor's subject knowledge, teaching skills, and desired outcome help determine the presentation technique. The instructional methods listed below are described individually, yet may be combined depending on the learning objectives or situation (Johnson, 1993).

The lecture is an instructor directed training method used mainly for the delivery of information. Many people may be reached with minimal effort via lecture. Interaction with the learner is incidental. It is one of the most commonly used methods despite being relatively ineffective. Lecture should be limited to focusing on one or two points and thirty minutes maximum.

The second method is presentation. Presentation may be considered an informal lecture. The instructor develops effective lesson plans that allow student interaction. The lecture portion of a presentation shouldn't exceed ten to fifteen minutes and aids (handouts, overheads, audio/video, etc.) are used to support the material presented. Presentation is also referred to as the workshop method (McCahon, Rys, & Ward, 1996).

Discussion is used to quickly identify the current level of student understanding. The trainer asks open-ended questions and uses the responses to determine the students' level of understanding. Instruction is then geared toward increasing knowledge and meeting learning objectives. Variations include panel discussion and small group discussion. A panel discussion may include subject material experts (SMEs), debate, and audience interaction. Small group discussion is implemented to experience a hands-on approach. Groups break out for a predetermined amount of time then report their findings to the group as a whole.

Case studies were found to be the most effective training method for problem solving in four separate studies (McCahon, Rys, & Ward, 1996). They may be self-supporting or used with other training methods. Sufficient and accurate information is supplied to reduce confusion by individuals or groups. The process used to solve the case study may be more important than the answer or findings.

Role-playing and videos are also used to teach problem solving techniques. They provide realism, color, and variety when meeting training objectives. Games are used as ice breakers for groups. People are more willing to participate after learning coworkers or group members share similar ideals or goals.

Phillips Plastics Problem Solving Process course uses several different teaching methods. Each student will receive a course manual that explains the problem solving model, tools, and required internal processes. The course introduction and subsequent chapters are taught in workshop or presentation style. The pages of the manual are shown as overheads or in Microsoft PowerPoint. Students are encouraged to follow along and take notes. Each tool or step is accompanied by a reinforcement exercise. When appropriate, students are assigned to teams of six to eight members.

The course is conducted over two consecutive days. The second day is used for case studies. One study is a typical plastic processing problem: specks in parts. Another case study isn't plastic specific. This requires the members to work through the process by thinking in terms they may not be familiar with.

After completing the training exercises and case studies, students receive copies of the required forms with correct data for future reference. Additional blank forms are also supplied for future applications in their work areas.

Problem Solving Evaluation Methods

McCahon, Rys, and Ward (1996) describe training evaluation as systematic data collection used to determine if the training goals were met. The study sites research showing 90% of the companies who train will do evaluations. This indicates that training evaluation is important. The data gathered will be used to focus on training goals, training effectiveness, and cost effectiveness.

Training program evaluation should be broad based and ongoing. Three ways to evaluate programs are tests, critiques or course evaluations, and observation. Tests come in a wide variety such as narrative, essay, multiple choice, and true/false. These are paper and pencil style tests that help measure knowledge. Case study tests allow the evaluation from information presented during the problem solution discussion period. Performance tests are used to verify a skill such as typing or operating machinery (Johnson, 1993).

Critiques and course evaluation is used at the completion of a course. The purpose is to get the immediate reaction of the student. They allow insight to the participant's perception of the program.

Johnson feels that observation evaluation is an important part of program evaluation and describes two methods. The first method is impromptu evaluation. Impromptu observation is unannounced and reflects how things really happen in the workplace. The observer may identify individual attitudes, interaction with coworkers, and preparation and execution of tasks.

The second observation method is scheduled observation. Scheduled observation allows time for preparation. Individuals will do what they believe is expected. Again, the observer may look for preparation and execution of duties, interaction with coworkers, and attitudes.

When the results of both types of observations show little difference, employees understand the correct methods and expectations. Large differences indicate problems that cannot be corrected by training (Johnson, 1996).

Evaluation at Phillips Plastics is consistent with what has been described so far in this evaluation section according to Sue Bergstrom, former Phillips Plastics Manager of Training and Operational Development. (S. Bergstrom, personal communication, February 2004). She also stated that Phillips Plastics is developing a training evaluation plan using the four level model created by Donald Kirkpatrick (Kirkpatrick, 1998). Kirkpatrick's model lists the levels (from lowest to highest) as reaction, learning, behavior, and results.

Level one is reaction. The participant's reaction to the training is evaluated. Kirkpatrick calls it a measure of customer satisfaction. Surveys are developed seeking quantified responses, standards are established, and the differences between the survey results and the standards are measured. Appropriate actions are taken as required. Phillips Plastics requires a reaction evaluation for all in-house and outside training.

Level two is learning. Learning is defined by Kirkpartick as the extent participants change attitudes, improve knowledge, or increase skill as a result of attending a program. Learning evaluation is accomplished using pen and pencil or performance tests. Both of these types of tests were described previously. Phillips' training staff uses pre and post tests regularly to determine advances in learning. Bergstrom has identified

Phillips Plastics to be at level two. The results of this research will help lay ground work to document progression into level three, behavior.

Behavior is described as the extent of change as a result of a participant's training. For change to occur the person must have a desire to change, know what to do and how to do it, work in the right climate, and be rewarded for changing. Change may not occur immediately and cannot happen until the opportunity exists. For example, a machine manufacturer may train a customer on equipment that will be delivered in the future. Change cannot occur until the equipment is in the customer's facility and production ready.

Bergstrom believes the behavior level is the next level of evaluation needed at Phillips Plastics. Methods need to be developed and implemented yielding accurate results of training programs.

Kirkpatrick's fourth level is results. Training programs are established to reach goals. While driving, a driver must know the present location in order to reach the proper destination. The same is true for training. It's important to know where the program is in terms of goals to reach that goal. The goal may be higher sales, increased profits, scrap reduction, or another goal set by the organization. Accurately evaluating the final results lets the organization know where it is. Phillips Plastics will develop plans to reach this level after reaching level three.

Summary

People have been required to solve problems since the beginning of time. The scope of problem solving grew and the consequences became financially more critical in the last century. Scientific methods, models, and tools were developed and customized by organizations. Phillips Plastics has developed and implemented a model used by Mold Technicians and others to help solve production problems.

Organizations worldwide teach employees problem solving skills. The instruction may use internal or external staff or possibly the Internet. Problem solving courses use a variety of training methods including lecture, presentation, or case studies. Phillips Plastics Problem Solving course is a two day presentation style class. Case studies focus on application of the tools and techniques taught.

Of the companies that train employees, 90% conduct evaluations. Evaluation may be as simple as a survey or more complex requiring data from several departments. Phillips Plastics evaluation is based on a four step model. The four steps are reaction, learning, behavior, and results. The reaction level is the participant's satisfaction level with the training. The learning level measures the gain in skill or knowledge or a change in attitude. The behavior level is the extent of a change in behavior. The fourth level is results. The final results of participating in the training are scrutinized.

Phillips Plastics is moving into the third phase, behavior. Surveys, tests, and observations are used to determine the effectiveness of the courses in the Mold Tech Development Program. This fulfills the needs of the first two phases, reaction and learning.

This research will evaluate the use of five problem-solving tools as reported by Mold Technicians who have completed the Problem Solving course. It may also serve as a model for Phillips Plastics Corporation in the development of Kirkpatrick's third phase of evaluation, behavior.

Chapter III: Methodology

Description of the Study

This research was conducted to assess the use of five problem solving tools taught in the Problem Solving course at Phillips Plastics Corporation (PPI). Productivity improvements and cost savings that were reported from using the problem solving tools are listed. Additionally, it assessed the utilization of the problem solving process in the work routine of the study participants.

Methodology

Participants voluntarily completed a written survey designed for this study. It was distributed and collected using the Phillips Plastics Corporation internal mail system. The results were tabulated and reported in Chapter Four.

Population/Sample

The subjects of the field study were eighty-five Mold Technicians from eight PPI business units in Wisconsin. The initial survey was distributed to 35 Mold Technicians at five facilities in West Central Wisconsin. A second mailing to 50 Mold Technicians at three additional business units in Medford and Phillips, Wisconsin was implemented per the back up plan. Phillips Plastics People Services identified the Mold Technicians and distributed the appropriate materials at each plant. Only data from Mold Technicians who have completed the 12-hour problem solving course was analyzed. Participants gave their implied consent by responding to the survey.

Instrumentation

A 17 item survey was used to collect data for the study. It solicited both demographic information and responses pertaining to how the Mold Technicians utilize the five problem solving tools, what cost savings or productivity gains resulted from using the five problem solving tools, and how Mold Technicians use the five problem solving tools in their daily work lives. The five problem solving tools targeted in this research were brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagrams.

The first item in the survey was a qualifier. Four choices were listed to a question asking when the participant completed the Problem Solving course. Surveys were not used if the participant did not complete the course.

Items 2 through 8 queried demographic information. The respondent was asked to check the most applicable answer from the choices listed. Examples of information collected in this section include years of employment at Phillips Plastics, Mold Technician classification, and the shift worked.

Items 9 through 17 gathered data specific to how the Mold Technicians utilize the five problem solving tools, what cost savings or productivity gains resulted from using the five problem solving tools, and how Mold Technicians use the five problem solving tools in their daily work lives. The five problem solving tools targeted in this research were brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagrams. Applicable responses were listed for questions nine through twelve. The respondent checked the most accurate response(s).

The last five items were Likert Scale statements. The respondent was asked to circle the most appropriate answer on a five point scale. The responses were strongly disagree, disagree, neutral, agree and strongly agree. Items 13 and 17 were applicable to all three research questions listed below. Items 14, 15, and 17 were used to determine if the Mold Technicians' reported cost savings as a result of using the problem solving tools. Item 16 solicited data on the Mold Technician's utilization of the five problem solving tools and integration into their work lives.

Space was available at the end of the questionnaire requesting feedback or suggestions. The time required to complete the questionnaire was approximately ten minutes. A copy of the questionnaire is in the appendix.

The research questions for this study are:

1. How do Mold Technicians use the problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagramming as taught in the Phillips Plastics Problem Solving Process course.
2. Are there significant improvements in productivity and cost/benefit as a result of using the problem solving techniques taught in the Phillips Plastics Problem Solving course? If so, what are they?
3. How is the problem solving process integrated into the Mold Technicians work routine?

Limitations

The use of human subjects is a limitation. It is assumed the Mold Technicians involved in the study will provide accurate information. The information may come from documented examples or be an opinion of the Mold Technician at the time.

The questionnaire was designed specifically for this research study. No validity or reliability has been established.

The results of the study should be used with related documentation when making critical or financial decisions. This is warranted by the limitations listed above.

Table 5

Listing of Tables Used in Chapter IV

Type of Analysis	Survey Item Number(s)	Table Number	Purpose
Tabulation	1,2,3, and 4	6	Demographic information
Tabulation	1,5,6,7, and 8	7	Demographic information
Tabulation of Frequency and Percentages	9 (all respondents)	8	Use of five problem solving tools
Tabulation of Frequency and Percentages	9 (by location)	9	Use of five problem solving tools
Tabulation of Frequency and Percentages	16 (all respondents and by location)	10	Tools used to determine root cause
Tabulation of Frequency and Percentages	17 (all respondents and by location)	11	Tools used to determine solution
Cross Tabulation of Frequency and Percentages	12, 14	12	Number of teams and pre-implementation costs/savings
Cross Tabulation of Frequency and Percentages	12, 15	13	Number of teams and post-implementation costs/savings
Tabulation of Frequency and Percentages	11	14	Frequency of using problem solving tools
Cross Tabulation of Frequency and Percentages	12, 10	15	Number of teams and tool use as team member
Tabulation of Frequency and Percentages	13	16	Frequency of using problem solving tools alone
Cross Tabulation of Frequency and Percentages	12, 13	17	Number of teams and tool use alone

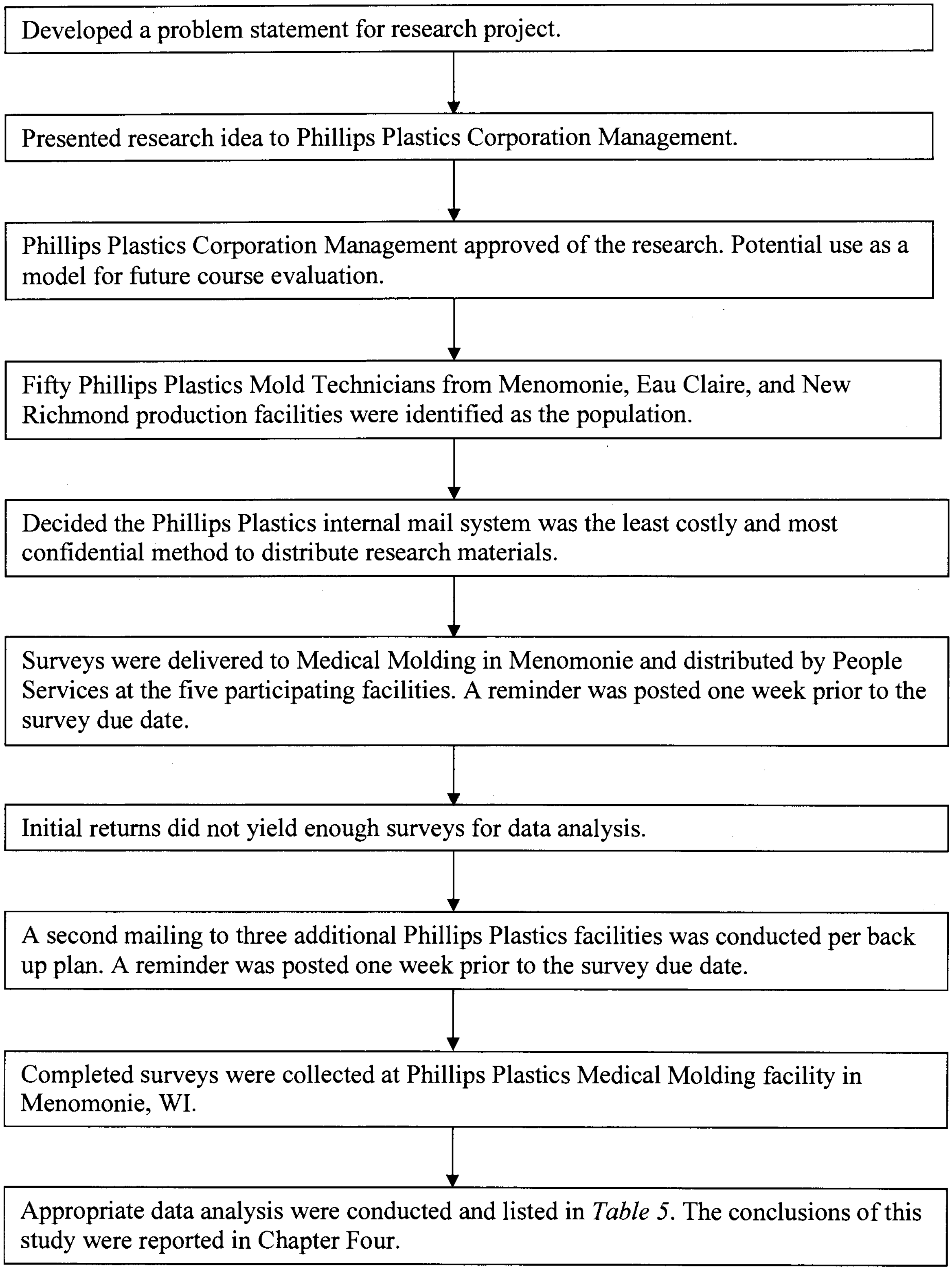

Figure 4. Process and Sequence Used to Conduct Research

Chapter IV: Research Findings

Introduction

The purpose of this study was to evaluate the use of five problem solving tools as reported by Phillips Plastics, Inc. Mold Technicians. The following questions were addressed in the study:

1. How do Mold Technicians use the problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagramming as taught in the Phillips Plastics Problem Solving Process course?
2. Are there significant improvements in productivity and cost/benefit as a result of using the problem solving techniques taught in the Phillips Plastics Problem Solving course? If so, what are they?
3. How is the problem solving process integrated into the Mold Technicians work routine?

Eighty-five Mold Technicians were asked by their division's People Services Representative to complete the Production Application of Phillips Plastics Problem Solving Course survey (see Appendix A). Thirty-five surveys were distributed at five production facilities in West Central, Wisconsin. These plants are Medical Molding and Assembly, MAG Molding, and Metal Injection Molding in Menomonie; Multishot in Eau Claire; and Short Run in New Richmond. Twelve (12) of 35 Mold Technicians completed and returned the survey for a return rate of 34.3%.

The People Services Representative at the Medford, Wisconsin Precision Decorating plant distributed surveys to 15 Mold Technicians. Seven returned the survey for a response rate of 46.7%. (See Appendix B.) The last distribution went to Custom I and Custom II in Phillips, Wisconsin. Thirty-five Mold Technicians were given surveys. Eight from this group replied. The return rate for Custom I and Custom II was 22.9% (see Appendix C).

Of 85 surveys distributed by People Services, 31 were returned. Two from the West Central group were not filled out. One person from a Phillips, Wisconsin facility completed the survey but did not complete the Problem Solving course. Data from these three surveys was not used. The data compiled for this study is from the 27 completed and returned surveys. The response rate for acceptable surveys at all eight plants was 31.8%.

Demographic Profile of Research Participants

Twenty-seven participants completed the demographic information listed in tables 6 and 7. Table 6 shows the year the respondent completed the Problem Solving Course, the number of years the participant has been employed by Philips Plastics, and the number of years the participant was employed as a Mold Technician. Twenty-six males and one female participated in the study. As required, all had completed the Phillips Plastics Problem Solving Course. Five completed it before 1997, eight between 1997 and 2000 and 14, or just over half, between 2001-2004.

Twenty respondents, or 74.1%, have been employed by Phillips Plastics Corporation for ten or more years. The second largest group worked at Phillips Plastics between four and six years. There were four Mold Technicians in this group representing 14.8% of the participants. Two employees worked three or less years comprising 7.4%. One employee had worked for Phillips Plastics seven to nine years or 3.7%.

Table 6

Years Employed at Phillips Plastics

Participant	Year Completed P/S Course	Years Employed at Phillips Plastics	Years Employed as Mold Technician
101	1997-2000	10 or more	10 or more
102	2001-2004	3 or less	10 or more
103	1997-2000	10 or more	7-9
104	2001-2004	10 or more	10 or more
105	2001-2004	3 or less	3 or less
106	Before1997	10 or more	4-6
107	2001-2004	7-9	4-6
108	Before1997	10 or more	10 or more
109	2001-2004	4-6	3 or less
110	Before1997	10 or more	10 or more
111	2001-2004	10 or more	7-9
112	Before1997	10 or more	10 or more
201	1997-2000	10 or more	4-6
202	Before1997	10 or more	10 or more
203	2001-2004	4-6	3 or less
204	1997-2000	10 or more	10 or more
205	2001-2004	10 or more	10 or more
206	2001-2004	10 or more	7-9
207	2001-2004	4-6	3 or less
301	2001-2004	4-6	4-6
302	1997-2000	10 or more	10 or more
303	1997-2000	10 or more	10 or more
304	1997-2000	10 or more	10 or more
305	2001-2004	10 or more	10 or more
306	1997-2000	10 or more	4-6
307	2001-2004	10 or more	10 or more
308 *	2001-2004	10 or more	4-6

KEY

Participant ID
100 = Eau Claire, Menomonie, and New Richmond, WI
200 = Medford, WI
300 = Phillips, WI
* Participant Number 308 was the only female respondent

The participants had from one to over ten years of experience as Mold Technicians. Fourteen, or 51.9% have been Mold Technicians for over ten years, three (11.1%) from seven to nine years, six (22.2%) between four to six years, and four (14.8%) indicated they had three or less years experience in that position.

Table 7 shows the respondent's job classification, work shift, the number of presses (molding machines) the Mold Technician is responsible for on a shift, and which Phillips Plastics plants they have worked at.

The respondents represented all five Mold Technician job classifications. There were nine Certified Mold Technicians (CMT) and nine Mold Technician IIs (MTII). Each of these groups represents 33.3% of the sample population. The balance consisted of three Mold Technicians from each of the following job classifications: Sample Technician (ST), Mold Technician I (MTI), and Mold Technician Trainee (MTT).

The participants represented five of the six work shifts listed on the questionnaire. The only listing not marked was "other". One Technician did not indicate a work shift. Twelve participants work either 8- or 12-hour day shifts, six work eight hour 3:00 p.m. to 11:00 p.m. shifts, and eight work either 8- or 12-hour nights.

The participating Mold Technicians reported they are responsible for operating from one to over ten molding machines. Fourteen operate ten or more presses during their shift. Eight are responsible for seven to nine presses. Two oversee four to six and three handle from one to three presses.

Table 7

Job Classification, Shift, Presses, and Facilities

Participant	Mold Tech Class	Shift	Presses Per Shift	Worked At
101	CMT	1st	10 plus	MM,MS
102	ST	1st	1-3	MAG
103	ST	3rd	4-6	MAG,CI
104	CMT	3rd	10 plus	MM,MS,IM
105	MTI	2nd	7-9	MAG,MM
106	MTII	12 hr PM	7-9	MS,IM
107	MTII	2nd	1-3	MAG
108	MTII	2nd	10 plus	MM
109	MTI	12 hr PM	7-9	MS,IM
110	MTII	12 hr AM	4-6	MS,IM
111	CMT	1st	10 plus	SR
112	MTII	1st	10 plus	SR
201	CMT	3rd	7-9	CI,CII
202	CMT	1st	10 plus	PD
203	MTT	3rd	7-9	CI
204	CMT	12 hr AM	10 plus	PD
205	MTI	3rd	10 plus	PD
206	MTII	12 hr AM	10 plus	PD
207	MTT	12 hr PM	10 plus	PD
301	MTII	2nd	10 plus	CII
302	MTII	1st	7-9	CI
303	ST	1st	1-3	IM,CI,CII
304	MTII	2nd	7-9	CI
305	CMT	1st	7-9	IM,CI,CII
306	CMT	?	10 plus	CI,CII
307	CMT	2nd	10 plus	CI,CII
308 *	MTT	1st	10 plus	CII

KEY

Participant ID
100 = Eau Claire, Menomonie, and New Richmond, WI
200 = Medford, WI
300 = Phillips, WI
* Participant Number 308 was the only female respondent

(Table 7 Key continued)

Mold Tech Class

MTT = Mold Tech Trainee	MTI = Mold Tech I
MTII = Mold Tech II	CMT = Certified Mold Tech
ST = Sample Tech	

Shift

1st	7 AM to 3 PM
2nd	3 PM to 11 PM
3rd	11 PM to 7 AM
12 hour AM	7 AM to 7 PM
12 our PM	7 PM to 7 AM

(Facilities) Worked At
SR = Short Run, New Richmond, WI
MAG = Magnesium Molding, Menomonie, WI
MIM = Metal Injection Molding, Menomonie, WI
MM = Medical Molding and Assembly, Menomonie, WI
MS = Multi-Shot, Eau Claire, WI
IM = Insert Molding, Eau Claire, WI
PD = Precision Decorating, Medford, WI
CI = Custom I, Phillips, WI
CII = Custom II, Phillips, WI

The information supplied by the participants indicates they tend to be long term employees who progress from Mold Technician Trainee to Certified Mold Technician at Phillips Plastics. The majority reported they are responsible for ten or more presses on their work shift.

Mold Technicians have a tendency to remain in the same geographical area while working for Phillips Plastics Company. Four employees of the 27 participants indicated they have worked in Phillips Plastics facilities outside of the geographical area where they are presently employed.

Research Question Number One

The first research question in this study asks: How do Mold Technicians use the problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagramming as taught in the Phillips Plastics Problem Solving Process course?

Survey items 9, 16, and 17 addressed question number one. In item 9, the participant indicated which of the five problem solving tools they have used. The five responses listed on the survey were brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagrams.

Items 16 and 17 were both were Likert Scale statements with five responses ranging from strongly disagree to strongly agree. Item 16 gathered information about the use of the problem solving tools to determine the root cause of a production problem individually or as a team member. Item 17 asked if the problem solving tools were used to find a solution to a production problem individually or as a team member. The total number of respondents for these items was 26.

The Mold Technicians reported that all five problem solving tools are used, although not to the same extent. See table Q1a. The most popular tool was brainstorming. Twenty-six of 27 respondents surveyed (96.3%) indicated they used brainstorming. The ask why technique was the second most used tool. Ask why was used by 20 out of 27 Mold Technicians. This represents 74.1% of the respondents.

Table 8

Reported Use of Five Tools at Plants Surveyed

	Brain-Storming	Ask Why	Flow Chart	Pareto Analysis	Fishbone Diagram
Respondent total = 27	26	20	11	4	6
Reported use (%)	96.3%	74.1%	40.7%	14.8%	22.2%

The use rate dropped below 50% for each of the last three tools. Flow charting was used by 40.7% (11 Mold Technicians). The least used tool was Pareto Analysis. Only four of the Mold Technicians reported using this technique. That translates to 14.8%. Six of the 27 (22.2%) have used fishbone diagrams.

The rank order for the five tools remained the same whether tabulated in total or by geographical location of the respondents. The Mold Technicians in the West Central facilities reported the highest frequency of use for all five tools. The results are sorted by geographical area in table 9.

Table 9

Reported Use of Five Tools by Geographical Area

	Brain-storming	Ask Why	Flow Chart	Pareto Analysis	Fishbone Diagram
West Central WI (12 responses)	12	9	7	3	6
Reported use (%)	100%	75%	58.3%	25%	50%
Medford, WI (7 responses)	7	5	2	1	0
Reported use (%)	100%	71.4%	28.6%	14.3%	
Phillips, WI (8 responses)	7	6	2	0	0
Reported use (%)	87.5%	75%	25%		

Brainstorming was the most frequently used problem solving tool. All of the West Central and Medford Mold Technicians reported using brainstorming. The reported use was 87.5%, or 7 out of 8 Mold Technicians, in the Phillips, Wisconsin plants.

The second most frequently used problem solving tool was ask why. This technique was used by 75% of the Mold Technicians in the West Central and Phillips areas and by 71.4% in Medford, Wisconsin.

This trend continued when the results were sorted geographically, yet the reported use shows disparity between geographical locations for the use of flow charting, Pareto analysis, and fishbone diagrams. The Mold Technicians in the West Central plants reported a higher frequency of use for flow charting (58.3%), Pareto analysis (25%), and fishbone diagrams (50%). The Phillips, Wisconsin Mold Technicians indicated that they do not use Pareto analysis. None of the Medford or Phillips, Wisconsin Mold Technicians reported using fishbone diagrams.

Question 16 in the survey queried the use of the tools to determine the root cause of a problem individually or as a team member. One respondent from Medford did not answer this question. Of the 26 who did, five Mold Technicians marked neutral (19.2 %). Eighteen (69.2 %) agreed and three (11.5%) strongly agreed that the tools were used to determine the root cause. There were no responses to disagree or strongly disagree that the tools helped determine the root cause. These results are shown in table 10.

Table 10

Use of Tools to Find Root Cause of a Problem

		Neutral	Agree	Strongly agree
West Central WI	Count (12 total)	2	9	1
	Valid % w/in Location	16.7 %	75.0 %	8.3 %
Medford, WI	Count (6 total*)	1	3	2
	Valid % w/in Location	16.7 %	50.0 %	33.3 %
Phillips, WI	Count (8 total)	2	6	
	Valid % w/in Location	25.0 %	75.0 %	
Total	Count (26)	5	18	3
	Valid % for all Locations	19.2 %	69.2%	11.5%

The results were similar by location. The West Central and Medford, Wisconsin facilities were identical with 16.7 % neutral that using the problem solving tools helped identify the root cause of a problem. These two locations also had identical percentages when combining responses of agreeing or strongly agreeing. Over 83% of the Mold Technicians in both West Central or Medford, Wisconsin indicated they agreed or strongly agreed that the problem solving tools were used to identify the root cause of a problem. The plants in Phillips reported 25% neutral and 75% agreeing that the problem solving tools helped determine a root cause.

Table 11 shows the response to the Likert Scale item 17 of the survey: The problem solving tools helped determine a solution to a production problem. Again, one participant from Medford did not respond.

Table 11

Use of the Problem Solving Tools to find a Solution by Mold Technicians

		Neutral	Agree	Strongly agree
West Central WI	Count (12 total)	2	9	1
	Valid % w/in Location	16.7 %	75.0 %	8.3 %
Medford, WI	Count (6 total*)		4	2
	Valid % w/in Location		66.7 %	33.3 %
Phillips, WI	Count (8 total)		8	
	Valid % w/in Location		100.0 %	
Total	Count (26)	2	21	3
	Valid % for all Locations	7.7 %	80.8 %	11.5%

Of the 26 participants, 80.8 % (21) indicated they agreed and 11.5 % (3) strongly agreed that the tools were used to find a solution. Two Mold Technicians marked neutral (7.7 %). There were no disagree or strongly disagree responses. Mold Technicians in either form of agreement to the statement that the tools were used to determine a solution totaled 24 or 92.3 %.

The results were similar when tabulated geographically. The Mold Technicians in West Central, Wisconsin indicated that nine (75 %) agreed, one (8.3 %) strongly agreed, and two (16.7 %) were neutral. The Mold Technicians at the Phillips, Wisconsin plants reported 100 % agreed and the Medford, Wisconsin Mold Technicians indicated four (66.7 %) agreed and two (33.3 %) strongly agreed that the tools helped find a solution to a production problem.

Question number one asks how Mold Technicians use the problem solving tools? The Mold Technicians participating in this research reported that they used all five problem solving tools. The tools are used to determine the root cause and solution to a problem.

The frequency of use for each of the five tools varied from 14.8 % to 96.3%. Brainstorming was the most popular problem solving tool and was used by all but one of the responding Mold Technicians. It was interesting that the West Central Mold Technicians reported the highest frequency of use for all five problem solving tools. One can only speculate a reason as data was not collected that would yield the necessary information.

The Mold Technicians may be using brainstorming and ask why more often because they are relatively easy to use and produce effective results. Less experienced

Mold Technicians quickly learn to utilize the tools of brainstorming and ask why by working on teams with experienced Mold Technicians. If success breeds success, the use of these techniques would spread to employees throughout the facility.

Fishbone diagrams are also easy to use. The diagrams may combine brainstorming and the ask why techniques with the four M prompts of machinery, manpower, method, and material. Because fishbone diagrams are easy to use and they combine tools already being used, it was interesting that none of the Medford or Phillips, Wisconsin Mold Technicians reported using them.

Almost 81% of the Mold Technicians indicated they agreed or strongly agreed that the tools helped determine the root cause of a production problem. They were even more assertive that the tools aided solving a production problem. In this category, 92.3% reported they agreed or strongly agreed that the problem solving tools helped determine the solution.

Research Question Number Two

Research question two asks: Are there significant improvements in productivity and cost/benefit as a result of the problem solving techniques taught in the Phillips Plastics Problem Solving course? If so, what are they?

Survey items 12, 14 and 15 addressed this section of the research. In item 12, the participant indicated how many problem solving teams they were on between September 2003 and September 2004. The four responses listed on the survey were one, two, three, and four or more teams. Eight Mold Technicians added zero (0) teams on the survey. This information was included in the tabulations when applicable.

Items 14 and 15 were both were Likert Scale statements with five possible responses ranging from strongly disagree to strongly agree. Item 14 gathered information about the estimated cost savings/benefits determined by a team before implementing a solution. Item 15 gathered information about the calculated cost savings/benefits after the solution was implemented. The total number of respondents for these items was twenty-three.

Table 12 is a cross tabulation of items 12 and 14. It shows how many teams a participant was on and the response to calculating cost savings/benefits before a solution was implemented.

Table 12

Reported Calculation of Cost Savings or Benefits Before Solution Implementation

Number of Teams		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Zero/none	Count	1	1	2	1		5
	% w/in group	20.0 %	20.0 %	40.0 %	20.0 %		100.0 %
1 team	Count	1	1	3	3	1	9
	% w/in group	11.1 %	11.1 %	33.3 %	33.3 %	11.1 %	100.0 %
2 teams	Count			4	1		5
	% w/in group			80.0 %	20.0 %		100.0 %
3 teams	Count			1			1
	% w/in group			100.0 %			100.0 %
4 teams	Count				3		3
	% w/in group				100.0 %		100.0 %
Total	Count	2	2	10	8	1	23
	Total %	8.7 %	8.7 %	43.5 %	34.8 %	4.3 %	100.0 %

Ten Mold Technicians out of 23 (43.5 %) indicated "neutral" to the statement that a team calculated cost savings or benefits before a solution was implemented. Two Mold Technicians strongly disagreed and two disagreed (8.7 % each) about teams determining cost savings or benefits before implementing a solution. Eight of the remaining participants agreed (34.8 %) and one strongly agreed (4.3 %) that teams calculated cost savings or benefits prior to solution implementation. The percentage in some form of disagreement was 17.4%. The combined percentage for Mold Technicians with some type of agreement was 39.1%.

Also shown in Table 12, nine of the participants (39.1%) were on one team in the 12 months preceding the survey. All five responses were used to the statement "cost savings or benefits were calculated by the team before the solution was implemented". One Mold Technician strongly disagreed, one disagreed, and three were neutral. Three others agreed, and one strongly agreed that cost savings were calculated before a solution was put into use in production.

The results were quite different for the three Mold Technicians who were on four teams. They agreed 100 % that cost savings or benefits were calculated before implementing a solution.

This higher percentage may indicate that additional responsibilities are attached to increased team participation, or maybe experienced team members have a better understanding of the monetary ramifications of their actions. Problem solving teams are typically held accountable for reporting proposed expenses to a monetary decision maker before implementation.

Five Mold Technicians noted on the survey that they were not on a team between September 2003 and September 2004. It was interesting that this didn't prevent them from expressing an opinion about a team's calculation of pre-implementation costs. Four of the five possible responses were marked. One Mold Technician strongly disagreed (20.0%), one disagreed (20.0%), two were neutral, (40.0%), and the last Mold Technician agreed (20.0%) that pre-implementation costs were determined. This may be a result of conversations between non team members and team members. Another supposition may be a negative response indicates a negative attitude by an employee who felt left out of the decision making process.

Item 15 of the survey was needed to ascertain if the Mold Technicians reported actual cost savings or benefits after the solution was implemented. Again, 23 Mold Technicians completed this item of the survey.

Table 13 is a cross tabulation of items 12 and 15. It shows how many teams a participant was on and the response to calculating cost savings/benefits after a solution was implemented.

Two respondents reported they strongly disagreed (8.7 %) and four disagreed (17.4%) that cost savings were calculated after implementation. Twelve (52.2%) indicated they were neutral. The Mold Technicians who strongly disagreed, disagreed, or were neutral comprised 78.3% (18 of 23) of those who felt cost savings were not calculated after implementation of a solution. The remaining five Mold Technicians (17.3%) reported that the teams they were on calculated cost savings or benefits after a solution was implemented. Three agreed (13.0 %) and two strongly agreed (4.3 %).

Table 13

Reported Calculation of Cost Savings or Benefits After Solution Implementation

Number of Teams		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Zero/none	Count	1	1	2	1		5
	% w/in group	20.0%	20.0%	40.0%	20.0%		100.0%
1 team	Count	1	3	3	1	1	9
	% w/in group	11.1%	33.3%	33.3%	11.1%	11.1%	100.0%
2 teams	Count			5			5
	% w/in group			100.0%			100.0%
3 teams	Count					1	1
	% w/in group					100.0%	100.0%
4 teams	Count			2	1		3
	% w/in group			66.7%	33.0%		100.0%
Total	Count	2	4	12	3	2	23
	Total %	8.7%	17.4%	52.2%	13.0%	4.3%	100.0%

A last part of the survey requested comments or suggestions. It was intended that information about specific projects would be reported here. No specific cost savings or benefits were reported in the comment section of the survey.

Question two asks: are there significant improvements in productivity and cost/benefit as a result of using the five problem solving tools? If so, what are they?

Slightly over one third (39.1%) of the Mold Technicians reported that the teams they were on calculated cost benefits or savings before implementing a solution. Ten (43.5%) indicated they were neutral to any pre-implementation calculations for savings. The remaining four disagreed or strongly disagreed (17.4 %). Indicating neutral suggests those Mold Technicians weren't aware of cost savings or benefits reported before project implementation. Combined with those who reported cost savings were not calculated, the majority (78.3 %) of the responding Phillips Plastics Mold Technicians believe cost savings or benefits were not calculated prior to putting a solution into production. Without data on anticipated cost savings, supervisors and managers have a difficult time justifying expenses for projects.

Even fewer Mold Technicians indicated that cost savings or benefits were calculated after a solution was put into production. Five Mold Technicians (17.3 %) reported they knew of actual cost calculations by a team. The majority, 12 out of 23, marked neutral (52.2%). Six (26.1%) disagreed or strongly disagreed. Combining the Mold Technicians who were neutral with those in either form of disagreement yields 78.3% believing that costs were not calculated after implementation.

These results indicate project evaluation after utilization in production may not be a common practice at the Phillips Plastics plants surveyed. Problem solving teams are established to solve a current production problem. Teams are normally disbanded after the solution is determined or implemented. It is reasonable to suggest the lack of follow through be contributed to the existence of current production issues taking precedence over past problems. This is further complicated as many teams disband after a solution is implemented.

The participating Mold Technicians did not provide information about cost savings or benefits resulting from the use of the five problem solving tools. This parallels the research data that shows the majority of the participating Mold Technicians were unaware of calculated pre or post implementation costs or benefits.

Research Question Number Three

Research question number three asks "How is the problem solving process integrated into the Mold Technician's work routine"? The information used to respond to question three comes from items 10 -13 of the survey. Item 10 was yes/no asking if the problem solving tools were used between September 2003 and September 2004. Item 11 queried the frequency of problem solving tool use. Participants who answered "no" to item 10 were instructed to skip to item 12. It should be noted that eleven participants answered "no" to item 10 and skipped item 11 as instructed. Consequently, there were sixteen respondents to item 11.

For item 12, the participants indicated how many problem solving teams they were on between September 2003 and September 2004. The four responses listed on the survey were one, two, three, and four or more teams. Eight Mold Technicians added zero (0) teams on the survey. This information was included in the tabulations when applicable.

Item 13 reads "I have used the problem solving tools from the Phillips Plastics Problem Solving course to solve production problems by myself." The five responses were Likert Scale ranging from strongly disagree to strongly agree.

Eight of the 16 respondents to item 11 (50.0 %) reported using the five problem solving tools on a daily basis between September 2003 and September 2004. See table 14. One (6.3 %) used the problem solving tools weekly, three (18.8 %) monthly, and four (25.0 %) used the tools less than once per month during the same time period.

Table 14

How Often Problem Solving Tools Are Used

	Frequency	Percent
less than once/month	4	25.0 %
monthly	3	18.8 %
weekly	1	6.3 %
daily	8	50.0 %
Total	16	100.0 %

Table 15 is a cross tabulation between the number of teams (item 12) and use of the tools as a team member (item 10). One Mold Technician didn't respond and eight indicated they didn't participate on a problem solving team nor use the tools as a team member. Data from the 18 Mold Technicians who participated on teams was used in order to project accurate information on the use of the problem solving tools by teams.

Three Mold Technicians, 16.7%, reported they did not use the problem solving tools as a member of a team. The remaining 15 respondents, 83.3%, indicated they used the problem solving tools as team members from September 2003 through September 2004.

Table 15

Team Use of the Five Problem Solving Tools

Number of Teams		Used Problem Solving Tools as a Team Member? Yes	No	Total
1 team	Count	7	2	9
	Percent w/in group	77.8 %	22.2 %	100.0 %
2 teams	Count	4	1	5
	Percent w/in group	80.0 %	20.0 %	100.0 %
3 teams	Count	1		1
	Percent w/in group	100.0 %		100.0 %
4 teams	Count	3		3
	Percent w/in group	100.0 %		100.0 %
Total	Count	15	3	18
	Percent Total	83.3 %	16.7 %	100.0 %

The participating Mold Technicians reported in item 13 the use of the problem solving tools by themselves to solve production problems (Table 16). Eighteen of 27 (66.7 %) marked that they agreed to the statement "I have used the problem solving tools from the Phillips Plastics Problem Solving course to solve production problems by myself." Four strongly agreed to this statement (14.8 %). The total percentage of Mold Technicians who reported using the tools by themselves was 81.5%.

Three Mold Technicians reported they were neutral (11.1 %) and two (7.4 %) indicated that they strongly disagreed they've used the tools alone.

Table 16

Individual Use of the Five Problem Solving Tools

	Frequency	Percent
strongly disagree	2	7.4 %
disagree	0	0.0 %
neutral	3	11.1 %
agree	18	66.7 %
strongly agree	4	14.8 %
Total	27	100.0%

A cross tabulation was compiled from data collected in item 12, how many teams the Mold Technician was on, and item 13, use of the problem solving tools alone. See the following table 17.

Table 17

Team Members' Individual Use of the Five Problem Solving Tools

Number Of Teams		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total
Zero/none	Count			2	5	1	8
	Percent w/in group			25.0%	62.5%	12.5%	100.0%
1 team	Count	1		1	5	2	9
	Percent w/in group	11.1%		11.1%	55.6%	22.2%	100.0%
2 teams	Count				5		5
	Percent w/in group				100.0%		100.0%
3 teams	Count				1		1
	Percent w/in group				100.0%		100.0%
4 teams	Count	1			1	1	3
	Percent w/in group	33.3%			33.3%	33.3%	100.0%
Total	Count	2		3	17	4	26
	Percent Total	7.7%		11.5%	65.4%	15.4%	100.0%

The majority of the responding Mold Technicians, 80.8 %, reported they agreed or strongly agreed that they used the problem solving tools by themselves. Six of eight Mold Technicians who were not on a team either agreed or strongly agreed they used the problem solving tools alone. Seven of nine Mold Technicians on at least one team indicated they also agreed or strongly agreed to using the tools alone. One hundred percent (100%) of the participants on two or three teams reported they used the tools alone.

It's interesting that Mold Technicians who were on four or more teams reported the smallest percentage of the combined agreeing choices. This group consisted of three Mold Technicians. Two thirds, or 66%, agreed or strongly agreed that they used the tools alone. One strongly disagreed to that statement.

Considering the frequency counts and percentages from tables 14, 15, 16, and 17, it's apparent the Mold Technicians have integrated the problem solving tools into their work lives. The majority indicated they use them daily or weekly (56.3%), alone (81.5%), or as a team member (83.3%). Three more reported using the tools monthly.

Only 14.8% of the participating Mold Technicians reported using the problem solving tools less than once per month. Mold Technicians who indicated they did not use the tools by themselves (7.4%) or as a team member (16.7%) are also smaller groups.

Summary of Chapter Four

Research Question Number One. How do Mold Technicians use the problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagramming as taught in the Phillips Plastics Problem Solving Process course?

The Phillips Plastics Mold Technicians reported the use all five problem solving tools. The most frequently used tool was brainstorming. Ask why was number two. The problem solving tools were used more frequently in the West Central Wisconsin plants.

The tools were used to determine the root cause of a production problem by almost 81% of the responding Mold Technicians. The problem solving tools were used to solve production problems by 92.3% of the respondents.

Research Question Number Two. Are there significant improvements in productivity and cost/benefit as a result of using the problem solving techniques taught in the Phillips Plastics Problem Solving course? If so, what are they?

Almost 40% of the Mold Technicians reported that the teams they were on calculated costs/benefits before implementing the solution. Fewer (17.4%) indicated follow up research was conducted to determine the actual cost/benefit after implementation. Problem solving teams are frequently established to resolve an immediate concern. Teams are disbanded after implementation. This would be a logical explanation why little data was collected after a solution was implemented.

The comment section in the survey was intended for collecting specific cost/benefit information. It was not written well enough to communicate these intentions to the Mold Technicians. No information was reported relating to specific projects or the cost/ benefit.

Research Question Number Three. How is the problem solving process integrated into the Mold Technician's work routine"? The information reported by the Mold Technicians indicates they have definitely integrated the problem solving tools into their work routines. The majority (56.3%) reported the use of the problem solving tools daily or weekly. The problem solving tools were also used by 81.5% of the Mold Technicians alone and by 83.3% on teams.

Chapter V: Conclusions and Recommendations

This final chapter summarizes the research of assessing the use of the five problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagrams as reported by Phillips Plastics, Inc. Mold Technicians. Conclusions and recommendations for further study will also be provided.

Summary

The summary considers the need and purpose of this research, the research questions, and the approach used in this research.

The Need and Purpose

Education is an important part of the corporate philosophy at Phillips Plastics as the company's growth and life is credited to the skills and strength of its people. This culture opens the door to education and training. The cost of educating a workforce of 2,000 people is significant. The company website states that 3 to 4% of the annual payroll is invested on training or development. Employees complete a written survey after finishing the Phillips Plastics Problem Solving Process course. The survey solicits the student's immediate input, yet there is no documented evidence of actual use of the techniques to solve production problems.

The purpose of this research was to evaluate the Mold Technician's use of five tools taught in the Phillips Plastics Problem Solving Course. The targeted tools are brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagrams. Cost savings as a result of using the tools were also examined.

The Training Department at Phillips Plastics may use this research information to identify strengths or weaknesses in the Problem Solving course. A Phillips Plastics employee did not collect the data reported in this research. This external perspective may give insight to changes not previously considered.

The approach used in this study may also serve as a model for measuring the effectiveness of the techniques taught in other courses at Phillips Plastics.

The People Services representatives in the West Central, Medford, and Phillips, Wisconsin areas distributed surveys to eighty-five Mold Technicians soliciting information relevant to the research questions. Data for this research was analyzed from the twenty-seven surveys returned.

Research Questions

There are three research questions this study attempted to answer. They are:

1. How do Mold Technicians use the problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagramming as taught in the Phillips Plastics Problem Solving Process course.
2. Are there significant improvements in productivity and cost/benefit as a result of using the problem solving techniques taught in the Phillips Plastics Problem Solving course? If so, what are they?
3. How is the problem solving process integrated into the Mold Technicians work routine?

Conclusions

Conclusions for this research will be based on a review of each research question used to guide the research and the results of the statistical analysis done in response to each question.

Research Question Number One. The first research question was "how do Mold Technicians use the problem solving tools of brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagramming as taught in the Phillips Plastics Problem Solving Process course?"

The Mold Technicians responding via the survey reported the use of all five problem solving tools. Using frequency tabulations, the most popular tool was brainstorming. This technique was reportedly used by 96.3% of the respondents.

The second most used tool was ask why. Twenty of 27 or 74.1% reported using this technique between September 2003 and September 2004. The rank order for frequency of use of the last three tools was flow charting (40.7%), fishbone diagrams (22.2%), and Pareto analysis (14.8%).

It is interesting that the Mold Technicians in the West Central, Wisconsin area reported a higher frequency of use of all tools than the Medford or Phillips, Wisconsin respondents. However, the rank order remained the same. The data collected for this research was not specific enough to explain the discrepancy. An explanation may be that the training facility is located in the West Central area. Possibly the Mold Technicians have more access or contact with the Problem Solving course instructor. Extra help from the trainer would assist the Mold Technicians in developing problem solving habits that include frequent use of the tools.

The use of the problem solving tools to determine the root cause of a production problem was reported by an overwhelming majority of the Mold Technicians. Almost 81% reported that they used the tools to determine the root cause of a problem.

The use of the problem solving tools to solve a production problem was reported by an even larger number of Mold Technicians. In total, 92.3% reported that they used the tools to solve a production problem.

The data suggests that the Mold Technicians do indeed use all five problem solving tools as taught in the Phillips Plastics Problem Solving course and that they use the tools to identify the root cause and solution to production problems.

Research Question Number Two. Survey question number two poses "are there significant improvements in productivity and cost/benefit resulting from the use of the problem solving techniques taught in the Phillips Plastics Problem Solving course? If so, what are they?"

A cross tabulation of the number of teams Mold Technicians participated on and responses to the Likert scale statement "in working with a problem solving team, cost savings were calculated before implementing a solution" was used in part to address question number two. In order to receive approval to implement a solution, the appropriate management level must typically approve the costs and benefits.

The data supports the fact that some teams did calculate the costs of the solution before implementation. Eight of the 23, or 39.1%, of the Mold Technicians responding reported that teams they were on actually calculated costs before a solution was put into production.

Only 17.4% disagreed or strongly disagreed that teams they were on calculated costs before implementing the solution. A neutral response was indicated by 43.5% who were apparently undecided on the matter. Consider that reporting neutral suggests costs were not calculated. Adding the neutral Mold Technicians to those who indicated costs savings were not calculated brings the total in disagreement to 60.9%. This now represents a majority reporting pre-implementation costs were not part of the team's problem solving process.

The three Mold Technicians who participated on four teams reported quite different data that supports pre-implementation cost calculations as part of the problem solving process. All three agreed that cost savings were calculated before implementation. Mold Technicians with the highest skill level are more frequently asked to participate on a team to facilitate faster and potentially more effective results. The fact 100% of the Mold Technicians who were on four teams agreed that preimplementation costs were determined may indicate experienced team members have a better understanding of the necessity of cost reporting in the problem solving process.

A second cross tabulation was used to determine if teams calculated post implementation costs. This is important to support the solution by verifying the costs/benefits that were estimated before implementation. It will also promote the establishment of future problem solving teams.

The Mold Technicians reported that fewer projects were evaluated for costs after implementation than before implementation. Five of the 23 respondents, or 17.3%, indicated their teams calculated the costs/benefits after the solution was in production.

Six Mold Technicians (26.1%) indicated the teams they were on did not calculate post implementation costs. Twelve were neutral. Combining the Mold Technicians who disagreed or were neutral represents that potentially 78.3% of the problem solving teams did not calculate costs after the project was implemented.

The last part of the survey asked for comments or suggestions. It was intended that information about specific projects be reported here. No specific cost savings or benefits were reported.

Research Question Number Three. The third question of this research was "How is the problem solving process integrated into the Mold Technicians work routine?" Fifty percent (50%) of the respondents reported using the problem solving tools on a daily basis between September 2003 and September 2004. Twenty-five percent (25%) reported using the tools weekly of monthly in the same period. This is evidence that the Mold Technicians at Phillips Plastics frequently rely on the tools to assist them in their work.

The majority of the responding Mold Technicians also reported using the five problem solving tools alone and as team members. Item 13 of the survey stated "I have used the problem solving tools from the Philips Plastics Problem Solving course to solve production problems by myself." Eighteen out of 27, or 66. 7% agreed and four more strongly agreed to this statement. A composite total of 81.5% of the Mold Technicians reported using the problem solving tools alone.

Eighteen Mold Technicians reported that they were members of at least one team from September 2003 through September 2004. Fifteen out of this group, 83.3%, indicated they used the problem solving tools as members of a team.

The data analyzed for this research indicates that the Mold Technicians have integrated the problem solving tools into their work lives. The majority reported to have used the tools daily, weekly, or monthly. The problem solving tools are used alone by 81.5% and as team members by 83.3% of the Mold Technicians responding to the relevant survey questions.

Limitations

Time was a limitation in this study. Mold Technicians are employed at several facilities throughout Wisconsin and work different shifts. A diverse group of Mold Technicians from several production facilities provided data. Every effort was made to ensure that each Mold Technician was given ample or equal time during data collection.

The use of human subjects is a limitation. It was assumed the Mold Technicians in the research provided accurate information. This information have been an opinion of the Mold Technician on the day of the survey.

Measurement tools and surveys were of the author's design and have no documented measures of validity or reliability.

The results of the study should be used with other related documents when making critical or financial decisions. This is warranted by the limitations listed above.

Recommendations

The following recommendations for further investigation are suggested as a result of this research:

There was a considerable amount of data collected via the survey that could be examined for other reasons. For example, how does the number of teams a Mold Technician participated on relate to the time in position? Another question that may be studied using the information gathered in this research is how does the frequency of use of a particular problem solving tool relate to the length of service as a Mold Technician? Answers to these questions may assist the training department in team development instruction or emphasizing a particular tool during the problem solving course.

Why does the data from this research indicate a discrepancy of problem solving tool use by geographical area? The Mold Technicians have all attended the same course. It seems that the tools used would be relatively equal from facility to facility as problems and teams are dealing with similar concerns. Follow up research may supply an answer.

It would be interesting to have Mold Technicians complete the survey in 2007 and compare the data to this survey. Changes in either direction would be valuable information for the Training Department.

Stronger or more direct information about the cost savings needs to be included in a follow up survey. Problem solving teams are usually cost driven and research that collects detailed information about costs, savings, and benefits would be useful to support the Training Department, Managers, and other decision makers. Monetary information drives decision making. Accurate monetary information with specific project examples may be used to explain the effectiveness or weakness of a training program. Managers could include financial information collected by teams in corporate reports. When budgets are tightened, training is frequently targeted for reduction. Documented proof and real life examples would benefit departments under financial scrutiny.

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Appendix A

Cover Letter

October 4, 2004

Dear Mold Technician,

I'm a graduate student working on a Masters Degree in Career and Technical Education at the University of Wisconsin-Stout. As a requirement for my degree, I must complete a research project. I've chosen to study the role of five problem solving tools in your work routine. The tools are taught in the Problem Solving course. They are brainstorming, ask why, flow charting, Pareto analysis, and fishbone diagrams.

I sincerely appreciate your cooperation in completing the attached questionnaire. It should require only a few minutes of your time. Please check or circle the appropriate response for each question. Return the completed survey to Lonna Brantner in the envelope provided via Phillips internal mail system by October 20th.

Your name will not be included on any documents. I do not believe that you can be identified from any of this information. Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. However, should you choose to participate and later wish to withdraw from the study, there is no way to identify your anonymous document after it has been returned.

This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact John R. Schultz or Dr Cruz. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

By completing the following survey you agree to participate in the project entitled, Assessing the Effectiveness of the Problem Solving Skills of Mold Technicians Who Have Completed the Problem Solving Course at Phillips Plastics Corporation.

Your responses will contribute to the successful completion of my research project and also assist Phillips Plastics continuous improvement process.

Sincerely,

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Appendix B

Survey