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A Dissertation

entitled

The Effects of Feedback and Goal Setting on Manufacturing Productivity Improvement: A Field Experiment in Manufacturing Cells

by

Timothy C. Stansfield

Submitted as partial fulfillment of the requirements for

the Doctor of Philosophy degree in

Manufacturing Management

Advisor: Dr. Deborah Dwyer

Graduate School

The University of Toledo

December 1997

An Abstract of

The Effects of Feedback and Goal Setting on Manufacturing Productivity Improvement: A Field Experiment in Manufacturing Cells

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Feedback and goal setting are widely endorsed by academics as an effective way to improve manufacturing performance. It would be expected that a fundamental concept so widely accepted would have established methodology for implementation and would be validated by field research. A review of the literature reveals that research on goal setting and feedback has included very few experiments in a manufacturing setting. These studies lack a proven methodology of implementation for manufacturing to specifically follow. They also lack an evaluation of information systems technology as a tool to assist with the implementation effort. Therefore, the use of goal setting and feedback as a significant tool to improve a company's competitive situation is not wide spread through today's

contemporary manufacturing.

To be a world-class competitor, discrete part manufacturers can utilize feedback and goal setting to improve productivity and manufacturing performance. The author contends that in order to foster the implementation of feedback and goal setting as a distinctive philosophy of world-class manufacturing, a proven methodology of implementation is necessary. This research involves a field experiment in furniture manufacturing and tests two methods of goal setting and feedback on productivity improvement across nine manufacturing cells. Three groups were used as control groups and two groups of three cells each received two types of goal setting and feedback intervention. The experiment included a baseline analysis of all nine cells over eight months and two months of intervention. By performing a field experiment with these concepts, this research evaluates alternative methodologies for implementation, shows that information technology can be the catalyst for implementation of these philosophies and suggests specific direction for future research.

The results of this research have shown that goal setting and feedback can significantly improve employees motivation and productivity. Secondly, an information system that provides feedback to the shop floor and facilitates the goal setting process can significantly improve productivity in a short period of time. Thirdly, an information system is a superior methodology to traditional training and supervisory intervention. And lastly, motivation can be improved through goal setting and feedback on the shop floor.

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CHAPTER 1
INTRODUCTION

The contemporary manufacturer is working in a globally competitive environment. Four avenues of competition have been identified including cost, quality, service and innovation (Mintzberg, 1989). Manufacturing is faced with the ominous effort of both cost reduction and quality improvement (Fredrickson, 1984). Opportunities for productivity improvement through improved labor efficiency and reduced production loss are critical to survival. These improvements must be incremental and continuous to respond to foreign competition, tighter customer demands and stockholder expectations (Doll and Vonderembse, 1990). Academic research providing knowledge and techniques to program this effort are indispensable. This includes organizational learning, statistical quality improvement and methods analysis, just to name a few. The domain of goal setting and feedback has also been shown to offer opportunity for improvement, but techniques to activate this effort have not been popular or commonly implemented in manufacturing at the shop floor level (Locke and Latham, 1984).

Extensive research has been performed in the areas of goal setting and feedback. This research has been primarily psychological and aimed at refining the motivation models. Research has generally been conducted in the laboratory, with

occasional field experiments. Nevertheless, few field experiments for this stream of research have been performed in actual discrete manufacturing settings.

Goal setting and feedback have been proven to improve productivity (Locke and Latham, 1984) and in general, the following is true:

Performance Goal Setting + Specific Performance Feedback = Productivity Improvement

Goal setting has been extensively researched to show improved performance. Laboratory research studies involving simple and complex tasks have shown performance improvement in simple problem solving, learning and other student experiments (Bavelas and Lee, 1978; Campbell and Ilgen, 1976; Campion and Lord, 1982; Erez and Zidon, 1984; Garland, 1984; Jackson and Zedeck, 1982; Kolb, Winters and Berlew, 1968; Locke, 1966; Locke and Bryan, 1968; Locke, Cartledge and Knerr, 1970; Locke, 1982; Locke and Shaw, 1984; Organ, 1977; Prichard and Curts, 1973; Shetty, 1979). Research in manufacturing settings has shown that goal setting improves productivity in manufacturing cells, logging, managerial objectives and total output (Buller and Bell, 1986; Early, 1985; Ivancevich, 1977; Locke, Shaw, Saari and Latham, 1981; Longenecker, Scazzero and Stansfield, 1994; Mento, Steel and Karren, 1987; Pritchard, Jones, Roth, Stuebing and Ekeberg, 1988; Raia, 1965; Sorcher, 1967; Stedry and Kay, 1966). Similar results in worker performance have been shown in service settings such as typing pools, answering phones, customer

service and hospital administration (Calpin, Edelstein and Redmond, 1988; Dossett, Latham and Mitchell, 1979; Erez and Arad, 1986; Hirst, 1988; Ivancevich and McMahon, 1982; Ivancevich, 1976; Hollenbeck and Williams, 1987; Yukl and Latham, 1978). Other settings for improvement through goal setting include higher sports performance (Anderson, Crowell, Doman and Howard, 1988), improved residential energy conservation (Becker, 1978), logging crew performance (Latham and Yukl, 1975), improved safety behavior (Marsh, Robertson, Duff, Phillips, Cooper and Weyman, 1995), elementary school children performance (Bandura and Schunk, 1981) and the level of creativity of individuals (Shalley, 1995).

One important component of goal setting rarely addressed within a manufacturing field experiment is feedback, yet the components for feedback are commonly measured and available in manufacturing situations. Feedback has generally been studied in laboratory settings and has shown to increase the levels of goal setting (Locke, 1968) and to result in higher levels of motivation (Bandura and Cervone, 1983; Campion and Lord, 1982; Early, 1986; Locke, Cartledge and Koeppel, 1968; Matsui, Payne and Hauty, 1983) and other performance enhancing behaviors (Okado and Kakuyama, 1982). In general, feedback can provide information about the type, extent and direction of errors so that they can be corrected (Becker, 1978). This is an important component of the research in this field experiment.

Given that it is a person's knowledge of his or her performance in relation to a standard that influences the subsequent amount of effort exerted and his overall

performance level, it is reasonable to conclude that both a difficult goal and knowledge of progress towards the goal are needed in order to maximize performance improvement. Many cases have actually studied the implementation of goal setting and feedback simultaneously and have not looked at the contribution of each separately (Dossett, Latham and Mitchell, 1979; Komaki, Barwick and Scott, 1978; Komaki, Heinzman and Lawson, 1980; Latham and Blades, 1975; Latham and Kinne, 1974; Latham and Saari, 1982; Latham and Yukl, 1976). By isolating these benefits separately, implementation methodologies and anticipated results can be developed for manufacturing.

Why hasn't goal setting and feedback been viewed as the panacea of manufacturing problems like MBO, MRP, JIT, TQM, self-directed work teams, Kaizen, and other "fad of the day" solutions to a competitive manufacturing environment? Although goal-setting and feedback have been utilized for productivity improvement in manufacturing (Latham and Yukl, 1975), it has not caught on like other management tools because a structured technique capable of responding to the ever-changing products, processes, markets, design changes etc. (Doll and Vonderembse, 1990), has not been blueprinted, tested or supported within the manufacturing arena (Kopelman, 1986).

Another shortcoming with the extensive line of research in this area is relating it systematically to manufacturing. Although some field experiments in manufacturing situations have been completed, the methodology of goal setting and feedback has not been the focus of documentation or inquiry. The actual

methodology of intervention has not been defined, nor have alternative methodologies been tested. Clearly, goal setting and feedback as an intervention have been defined in research, but no systematic approach to implementation in manufacturing has been shown that could ultimately become the model for varied manufacturing applications.

Computer enhanced systems and procedures are being developed for all manufacturing operations (Early, 1988) and are logical tools to provide feedback information on performance. These information system models developed to date have been driven towards the feedback side, not the goal setting side. Yet, research has shown that the motivational affect of feedback is really due to goal setting (Locke, Cartledge and Koeppel, 1968). It seems evident that a computer system that encouraged goal setting and provided feedback should be a required tool for manufacturing.

Edwin Locke and Gary Latham (1981), arguably the most noted researchers in the goal setting and feedback field, have specifically indicated that one opportunity for further research is to discover what type of feedback is most effective in the goal-performance relationship. A scientific approach to examine this knowledge privation is the focus of the proposed research.

Goal Setting and Feedback

Information and decision support systems have evolved over the past forty years to be responsive to our information needs. Specific applications in

manufacturing have been driven towards performance tracking and comparison to manufacturing standards and benchmarks. Information systems have provided information to users in "real time" fashion. This information, however, has been provided to management personnel for strategic decision making considerations, periodic performance reviews, and general trend analysis to ensure that no major problems occur. In other words, information systems technology has been utilized well to provide ongoing and even "real time" feedback to management, but front line workers rarely get information that they can use productively. In addition, the use of feedback to set more accurate and challenging goals has usually been conspicuously absent. This has been due to the difficulty of providing feedback in a timely manner.

Since manufacturing needs to exploit all opportunities for productivity improvement, information systems seem to be a logical tool and methodology to enhance this effort. Furthermore, Locke and Latham (1984) have identified the lack of a defined methodology of goal setting and feedback as a weakness within the current academic research and that is why this field experiment has been designed.

Other lessons from this research include the direction that the nature of work itself is taking. Improving worker productivity and satisfaction in a repetitive production task is a major concern for management (Zuboff, 1984). Such tasks are often viewed as monotonous, boring and fatiguing. This, in turn, may result in reduced worker productivity, reduced satisfaction and higher absenteeism. Furthermore, it may cause detrimental effects on a worker's physical and mental

well-being. Automation has been one answer to these problems (Hertzberg, 1981), but humans continue to endure as the most flexible resource for changing customer demands. The nature of work often results in muscular tiredness due to stressing specific muscles and the concentration necessary to perform a task (Niebel, 1988). Goal setting and performance feedback have been shown to have a positive impact in making the work more challenging, interesting, less boring and creating more job attention especially in a repetitive production task (Latham and Yukl, 1975). The potential for goal setting and performance feedback as a component of a job design approach has not been fully recognized nor utilized to their fullest extent in the real-world task situation for improving worker productivity and satisfaction.

Most of the research studies in goal setting and performance feedback have been conducted in laboratory settings with relatively simple or simulated tasks. The goal levels were established arbitrarily or based on the operator's past performance. Measured standards were seldom used. When attempts were made to verify the concepts in real-life tasks, the results were often conflicting due to the difficulty in controlling environmental variables. Additionally, it is difficult to get a company to commit to the experimental time frame and data requirements. Systematic controlled experiments have not been performed with a repetitive production task employing measured standards to determine the effects of various levels of assigned and participative goal setting with feedback on worker productivity and satisfaction.

Goal Setting and Feedback Model

As presented in Figure 1, the traditional goal setting/feedback model has been shown to improve satisfaction and motivation. Applying this model strictly to the manufacturing environment, goal setting and feedback have been shown to improve the traditional measures of manufacturing performance. Specifically, labor efficiency, capital utilization, quality and safety (Latham and Yukl, 1975) have improved in manufacturing environments through the utilization of goal setting and feedback.

The current experiment has been designed to isolate the goal setting and feedback variables while the mediating and moderating variables identified are being held constant. This experiment is designed to build upon the model shown in Figure 1 and test varied methodologies of goal setting and feedback in a manufacturing cell.

HOLLENBECK AND KLEIN MODEL

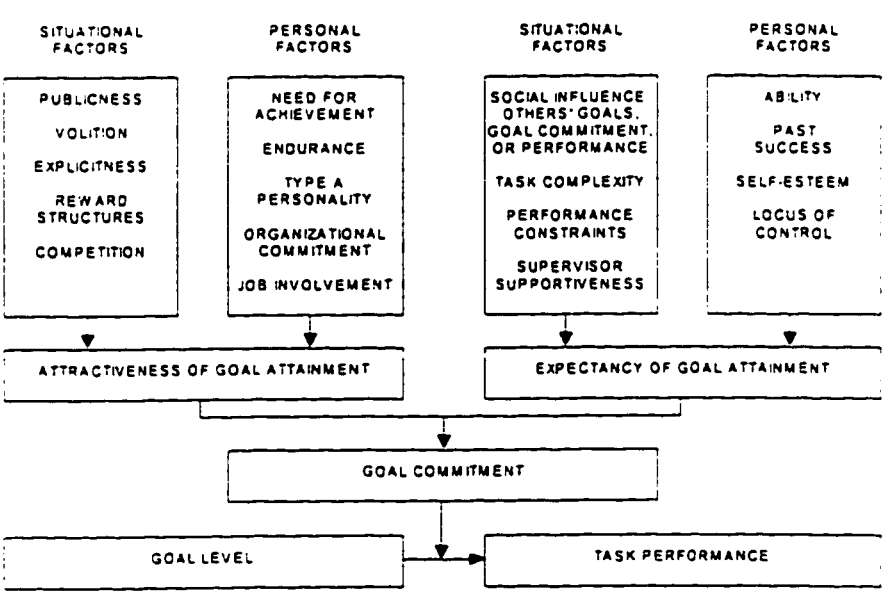

Figure 1

Problem Statement

Researchers contend that goal setting and feedback improve performance and therefore improve an organization's capacity to compete. Latham and Locke (1981) have clearly defined that one weakness in the current research is the type of feedback that is most effective. Furthermore, the global competitiveness of manufacturing has propelled companies to accept the challenge of using every opportunity for productivity improvement. Manufacturing is not currently capitalizing on the goal setting opportunities on the shop floor because no standard methodology or script has been prepared.

The general use of feedback through decision support systems regarding direct labor performance and self-set group goal setting has not been tested empirically on the shop floor. As stated by Locke and Latham (1990), the effective methods of feedback also offer tremendous opportunity for research. For these reasons, the current experiment is designed to measure productivity improvement through goal setting and feedback using several methods of intervention. Applications to manufacturing, methods of feedback, and predictive levels of improvement are the goals of this experiment.

Contribution of the Research

The intent of this research is to develop a model of efficient and implementable goal setting and feedback for manufacturing to improve productivity. The contribution of this research must serve numerous requirements. First of all, this

research must be consistent with Latham and Locke's (1981) model of goal setting and feedback. Second, the antecedents of feedback and goal setting methods used in this research must be consistent with the expectancy theory model for this stream of research presented by Hollenbeck and Klein (1987). Third, the utilization of information technology will be shown to be a viable option of information feedback and a benefactor of the goal-setting process.

The research question to be answered in this field experiment is as follows. *"To what extent can a manufacturing work cell utilizing an information system, which enhances goal setting and provides specific performance feedback to the employees, improve productivity?"*

CHAPTER 2
LITERATURE REVIEW

This chapter will present the previous research for goal setting and feedback. Specifically, the experiments involving goal setting and feedback, variables influencing these concepts, information technology applications in goal setting and feedback, and expectancy theory models are all presented as they relate to this research. In addition, the model development for this research, as well as the hypothesis development, is introduced.

Goal Setting

The importance of goal setting for motivating employees' performance was first explicitly recognized in the management literature by Taylor (1911). Edwin Locke (1968) then translated the concept into a contemporary theory of task performance. According to Locke's theory, if workers accept hard, specific goals, performance improves. In a review of goal setting, Locke, Shaw, Saari, and Latham (1981) viewed goal setting as primarily a motivational phenomenon, but acknowledged that it also involves cognitive elements. From a motivational standpoint, goal setting affects the direction, amplitude (effort), and duration (persistence) of action. From a cognitive perspective, goal setting is thought to affect

strategy development or ways to accomplish goals. The first three of these mechanisms are relatively direct in their effects on performance. Strategy development is more indirect because these factors are not directly linked to performance.

A review of over 140 laboratory and field studies on the effects of setting goals when performing a task found that in 90% of the studies, specific and challenging goals lead to higher performance than easy goals, "do your best" goals, or no goals (Locke, 1981). Locke states that goals affect performance by directing attention, mobilizing effort, increasing persistence, and motivating strategy development. Goal setting is most likely to improve task performance when the goals are specific and sufficiently challenging, the subjects have sufficient ability (and ability differences are controlled), feedback is provided to show progress in relation to the goal, rewards such as money are given for goal attainment, the experimenter or manager is supportive, and assigned goals are accepted by the individual. No reliable individual differences have emerged in goal-setting studies, probably because the goals were typically assigned rather than self-set.

According to Locke and Latham (1991), goal setting is a motivational technique that works. "It works" can be defined as improving individual or group productivity. This has been demonstrated in an analysis of twenty-five of the many laboratory experiments involving goal setting. These experimental laboratory studies obtained similar results regarding productivity improvement with a wide variety of tasks such as a figure-selection task, (Bavelas and Lee, 1978), five experiments

involving brainstorming, figure selection, and sum estimation tasks, (Bavelas and Lee, 1978), chess, (Campbell and Ilgen, 1976), a coding (credit applications) task, (Hannan, 1975), prose learning, (LaPorte and Nath, 1976), brainstorming (Latham and Saari, 1979b), simple addition, (Locke and Bryan, 1969b), three studies with reaction time and one study with simple addition, (Locke, Cartledge, and Knerr, 1970), perceptual speed, (Locke, Mento, and Katcher, 1978), card sorting, (London and Oldham, 1976), two studies of 4-5-year-old children working on a color discrimination task, (Masters, Furman, and Barden, 1977), two experiments using a perceptual speed task, (Mento, Cartledge, and Locke, 1980), and complex prose-learning studies (LaPorte and Nath, 1976; Sales, 1970; Rothkopf and Billington, 1975; and Rothkopf and Kaplan, 1972). All of these experiments have shown us that goal setting improves productivity.

Goal setting is thought to serve a directive function in an individual's estimates of his or her capacity to perform in the work environment. A series of studies were conducted by Earley (1991) in which college students performed mathematics problems or worked on a complex game simulation under conditions of easy or challenging goals supporting this function. In addition, Earley conducted a field study with junior and senior business students in a management course during a normal semester. Three alternative models combining self-efficacy expectations, performance valence, and personal goals were tested with LISREL VI and hierarchical regression analyses. The results produced by the experiment support the aspects of higher goal setting and in general, favor the causal relationships suggested

by Locke and Latham (1990) and Eden (1988).

However, not all of the research related to goal setting has been completed with concrete results. A field experiment conducted by Buller and Bell (1986) with 53 hard-rock miners in an underground metal mine examined the effects of two interventions, team building and goal setting on miners' productivity and strategy development. The study employed a 2 x 2 factorial design with random assignment of participants to the goal setting condition and it used objective criteria of performance. The results were inconclusive. Although slight improvements occurred in some measures of performance and strategy development, it is not clear that these improvements were a result of Buller's interventions. More of the improvements occurred in the goal setting than in the team building condition. Limitations in the research design and factors in the experimental setting that could not be controlled led to equivocality of the results.

Participation and Supportiveness

Participation has long been recommended by social scientists as a means of obtaining employee commitment to organizational goals and of reducing resistance to change. Nevertheless, an extensive review of the participation in decision-making literature by Locke and Schweiger (1979) found no consistent difference in the effectiveness of top-down ("autocratic") decision making and decisions made with subordinate participation. Specifically reviewed are those studies that involved participation in goal setting.

Carroll and Tosi (1970) included a measure of perceived participation in goal setting in a questionnaire administered at a manufacturing firm that had a Management by Objectives program. The results indicated that participation did not correlate significantly with employee perceptions of goal attainment or employee perception of increases in effort.

Negative results were also obtained in a field experiment by Ivanevich (1976). This study compared participative and assigned goal setting for sales personnel. Goals were set for each of four quantitative performance criteria. Although both goal-setting groups showed performance increases, no significant differences in performance were found between the participative and assigned goal conditions.

Latham et al. (1978) found that engineers and scientists in a participative goal condition set more difficult goals than their peers who had assigned goals. However, the perceptions of goal difficulty did not differ, and no significant differences in goal acceptance were found between the two goal conditions. The participative and assigned groups did not differ significantly in performance, although only the participative group significantly outperformed the control group.

These three studies indicate that participation in goal setting may affect performance through its influence on goal difficulty. Thus, if goal difficulty is held constant, participation should not affect performance. Participation may affect performance only if it leads to higher goals being set than is the case when a supervisor assigns them unilaterally.

The cognitive models of participation suggest that the increased quality of information that is brought to decision by workers, along with increased knowledge at implementation time, leads to increased productivity; merely working in a participative atmosphere is not enough to bring about a change. Affective models proposed that participation will increase job satisfaction in workers by satisfying higher-order needs. The contingency models of participation suggest that there is no single model of participation that will bring about a change for all workers in all organizations. Workers who value participation will be the ones most influenced by a participative climate.

Miller and Monge (1986) conducted a meta-analytic literature review of the effects of participation in decision making on worker satisfaction and productivity, testing cognitive, affective and contingency models. This review reports a meta-analytic literature review testing cognitive, affective and contingency models of the effects of participation in decision making on employees' satisfaction and productivity. Contingency models received no support. Results from field studies provided some support for cognitive models, and strong support for affective models linking participative climate with worker satisfaction. Methodological variations such as research setting and type of participant were important moderators to the experimenters in subgroup analyses.

Miller and Monge concluded that participation has a positive effect on the levels of goals set. But participation may not affect productivity if the goal levels remain the same; participation has an effect on both satisfaction and productivity but

the magnitude of the effect on satisfaction is greater than the effect on productivity. In addition, the researchers stated that there are organizational factors, such as leadership style or type of tasks, that may improve or constrict the effect of participation on satisfaction and productivity.

Participation has been shown to have a positive effect on the organizational commitment, level of goals, goal attainment and performance. This research has shown that participation must be a critical component of our research.

Feedback

Knowledge of performance in relation to the goal appears to be necessary if goals are to improve performance, just as goals are necessary if feedback is to improve performance. Feedback is probably most helpful as an adjunct to goal setting when the task is divided into trials and feedback is provided after each one, although the ideal frequency of feedback is not known. Feedforward, telling the subjects how fast they will need to work on a future trial as compared with their speed on an immediately preceding trial, may be a partial substitute in some cases (Mento et. al., 1980). Knowledge and feedback, of course, may have purely cognitive (learning) effects on performance (Locke, 1968), but these are not the concern of this review. Clearly more research is needed on feedback, especially research based on the issues raised by Ilgen et al. (1979), such as timing, frequency, source, interpretation, and so on.

The positive effect of knowledge of results or feedback on an individual's

performance is a well-established finding in academic research. Feedback can facilitate performance by providing information about the type, extent, and direction of errors so that they may be corrected: "Feedback has long been recognized as a key element in learning, based on a number of assumptions about the motivational, learning and reward properties of feedback" (Pritchard, Bigby, Beiting, Cloverdale and Morgan, 1981). Locke and Latham (1990) state that feedback is a moderator of goals in that it directs performance with more certainty. Additionally, Locke and Latham (1990) developed a model for explaining how feedback leads to performance. The feedback model shows that whenever an individual is given feedback about past performance it must be seen or heard (e.g., detected) and perceived, in order to be conceptually understood and translated into knowledge of results (e.g., cognitive appraisal) along with additional cognitive appraisals (e.g., accuracy, consequences). At the same time, based on the cognitive appraisal, a determination is made by the individual as to the importance, significance, goodness, badness, and so forth, of the knowledge of results (e.g., value appraisal) as it relates to their system of values. This value appraisal occurs as an emotional response.

Using the cognitive and value appraisals, the individual will make forecasts of the future and draw conclusions (e.g., ignore, improve). These forecasts and conclusions provide the individual with numerous courses of action (e.g., set goal to improve, change task strategy) that they can take. Although there have been few experiments regarding feedback and goal setting in actual manufacturing settings, many experiments in laboratory settings have been performed. The following

reviews a few of the most significant experiments and their conclusions regarding feedback.

Kim and Hamner (1976) investigated the effect of feedback and goal setting on performance and satisfaction in a large Midwestern telephone company. Four plants and 113 unionized blue collar workers participated in the study. A quasi-experimental, non-equivalent group design was used in this investigation. Baseline performance levels for the dependent variables were established. There were three objective performance measures (cost performance, absenteeism, and safety) that were used, along with one subjective measure as the dependent measures of productivity. A pre- and post-monthly Job Description Inventory Scales by Smith, Kendall and Hulin (1985) was used to measure job satisfaction. The management staff set initial goals for the 25 work groups from the job analysis figures. Weekly objectives were then set and given to the participants by their foreman. The plants differed on the amount of exposure to feedback in terms of knowledge of results and praise. Experimental group 1 (n=37) received extrinsic (supervisory) feedback only in the form of information from the foreman. Sometime during each week, the foremen would visit each worker and informally praise him/her for exceeding the past week's performance and/or the company's performance goals. Negative feedback was not allowed to be given. Experimental group 2 (n=26) received intrinsic (self-generated) feedback only. The foremen of each work group met with his workers to set or reemphasize the current week's goals. The workers would rate themselves concerning the performance measures. Experimental group 3 (n=26)

received both extrinsic and intrinsic feedback as well as praise. Goals were established by the workers with the supervisor. Additionally, the employees turned in the filled out rating forms to their supervisor which became the basis for the group's feedback and goal setting sessions. Every week the foreman would praise each worker individually when the performance improved or exceeded the established goal. Experimental group 4 (n=24) received goal setting instructions only. No formal feedback was given, however, informal feedback may have occurred.

The results of the study indicated that during the pre-treatment period, the cost performance among the four groups was significantly different ($F=10.62$, $p<.001$). At the end of the experimental period, the goal-setting plus informal feedback group (group 4) was the only group which failed to meet the cost objective. The highest level of safety performance was in the maximum feedback group (group 3) (goals + formal self feedback + extrinsic feedback + praise). The service (subjective) measure of job performance for all four groups was below the organization's objective and there was no significant difference among the scores ($F=-1.83$). After the treatment period, the intrinsic-feedback (knowledge of results only) group (group 2) had improved but was still below the service objective, while the goal setting group showed considerable improvement. There was no difference between the maximum-feedback group and the other formal feedback groups ($F=.56$) for the service objective. There was no significant change in the absenteeism rate which was already low. The pre- and post-level of worker satisfaction revealed that

feedback, when combined with goal setting, was not superior to goal setting alone in determining the perceived satisfaction level of workers. The researchers concluded that goal setting alone can improve performance without a formal knowledge of results program but when feedback is added to a goal setting program, performance improved beyond that found when only goal setting was used.

In another case, Erez (1977) conducted a study to investigate whether the knowledge of score (feedback) is a necessary condition for goal setting to affect performance. The subjects were 86 undergraduate students enrolled in two discussion groups of an introductory psychology course at a technological institute in Israel. A number comparison was used to discover discrepancies between two lists of numbers. One group was randomly assigned to the experimental condition; the other group was the control group. The experiment was performed in two stages. Stage one consisted of both groups performing the task within a ten minute period. Subjects in the experimental group were informed how they had performed in relation to others. No performance feedback was given to the control group. For the stage two subjects, level of intention or self-set goal was ascertained using a questionnaire that was administered to both of the groups. The subjects then performed a second number comparison task. Multiple regression was then used to analyze the data. The result of stage one indicated that the two groups did not differ significantly in performance (Group 1 mean = 9.82, Group two mean = 10.69, $t = 1.48$, $p > .05$). The stage two mean performance under the feedback condition (mean = 13.17) was significantly higher than under the no feedback condition (mean =

11.18, t = 2.35, p<.02). When the effect of feedback was controlled, goals were significantly and more strongly correlated to performance (t=.01, p<.05). Erez concluded that feedback is a necessary condition for goal setting performance.

A study by Becker (1978) used 100 randomly selected homeowners, located in central New Jersey, to examine in a field setting the motivational effects of feedback and goal setting on a task that involved residential energy conservation. Families that volunteered for the study were randomly assigned to one of five groups. Two of the groups, assigned a difficult goal, were asked to reduce their consumption by 20 percent. The families in two other groups were asked to reduce their consumption two percent, an easy goal. The families in the difficult goal group and easy goal group were given feedback about their conservation task performance. Families in the fifth group (a control group) were asked to continue their normal use of electricity and received no feedback. The goal difficulty and conservation levels were selected mainly from earlier raw data collected in the same community.

Feedback was given three times a week to participants via posted cardboard charts that were marked each feedback day. The families that were to get feedback were given charts that contained a graph on which was listed the goal, and the percent of energy conserved or wasted was plotted over time. The normal use, non-feedback (control) groups had spaces in which an X was made to confirm that the meter had been read, along with an "electrical jargon" goal statement which was written in. Also, these families were supplied with an information sheet listing appliances usually found in the home and the amount of electricity each used. The

control group was told that the researcher thought they might find it interesting. The experimental groups were told that they would find the information useful in deciding where to direct their conservation efforts. The 20 percent feedback group conserved the most electricity, 15 percent. The two percent feedback group conserved 5.7 percent, the 20 percent no-feedback group conserved 4.5 percent, and the two percent no-feedback group wasted 6 percent when compared to the control group. The greatest conservation occurred in the 20 percent (difficult) feedback group. The results of this study indicated that electricity conservation was facilitated most by the assignment of a specific difficult goal, and giving feedback about how well the goal was being achieved. Only the 20 percent feedback group performed significantly better than the control group ($p=<.05$).

Nadler, Cammann, and Mirvis (1980) investigated the effects of developing and implementing an ongoing feedback system in ten medium sized retail branches of a Midwestern bank. It was hypothesized that collaborative design activities would lead to the development of a new information system which would, in turn, lead to the development of a control process (goal setting, feedback and problem solving) that would result in increased levels of performance in work units and more effective behavior patterns.

The twenty branch banks involved were relatively independent organizational units, each having a staff that ranged from eight to twenty five people. A diagonal slice task force was created in order to have employee participation in the system's design and implementation. The task force, consisting of two branch managers, one

assistant manager, one financial consultant, two teller supervisors, two tellers, the authors (the researchers), and a representative of the vice president, met regularly for approximately three months to determine the financial and productivity data that was needed, the performance indicators, and the measures of human organization (e.g., number of specific tasks tellers were required to perform).

Survey data on employee attitudes and perception was collected. All data were reported in aggregated form, reflecting the level of activity of the group. The feedback reports were prepared and sent monthly to each branch manager for distribution to branch employees. Prior to the implementation of the system, one six-hour training session was held for the managers in the ten experimental branch banks.

A quasi-experimental nonequivalent (matched) comparison group design was used to evaluate the effects of the feedback system which was put into ten branches of the bank, while ten similar branches were used as a comparison group. Data was collected in all 20 branches to evaluate behavior patterns and work unit performance before implementing the system, and again after it had been in operation for one year. Information was collected on the new system's effect on the employees throughout the experimental year. Change scores were calculated by regressing the Time 2 scores and adding the residuals. The analyses were based on these residual change scores, and tests of experimental effects were made by examining the significance of the difference between the changes that occurred in the experimental branches and the changes in comparison branches.

The results of the study indicated that the feedback system had positive effects on some of the experimental work groups, but not on others. The positive effects were seen in the branches where the feedback was regularly used by managers to involve workers in their own control through goal setting and problem solving. Negative outcomes resulted in the branches where the new feedback system was not used or was poorly used. Nadler, Cammann, and Mirvis (1980) concluded that these study results supported the results of other studies cited in the literature that feedback alone may have little or mixed effects, but it is how the feedback is used for goal setting and problem solving that is critical (i.e., managerial usage).

In addition, well-designed feedback can improve decision making but to date there has been no comprehensive study of feedback in decision support systems (DSS) that could guide developers in its design. The work by Te'eni (1991) examines the opportunities and means to enhance cognitive control in decision making by providing appropriate feedback with DSS. It concentrates on the timing of feedback, which has been shown to affect the use of feedback and also demonstrates the potential advantages of using information technology over and above manual decision environments. Te'eni's two experiments test the effects of controlling the timing of cognitive feedback on the user's cognitive control. The first tests the effect of timing one source of cognitive feedback, and the second tests the effect of timing two sources of feedback. Results suggest that the DSS could become an effective and routine tool for the provision of feedback.

The conclusion is simple. Feedback works and it has an indirect effect to

improve productivity and performance by clarifying expectancies about what it takes to be successful (Hollenbeck and Klein, 1985). An important question, however, is what type of feedback is most effective? In addition, few experiments have been performed in actual manufacturing situations. Documentation of this experimental procedure in an actual manufacturing situation will offer insight into the applications of this important tool to manufacturing.

Manufacturing Information System Support

Despite the demonstrated importance of feedback for the successful implementation of many organizational systems, few research studies have examined the influence of computer-generated feedback on an individual. A field experiment was conducted by Earley (1988) to assess the relationship of computer-generated feedback to an individual's task performance. Sixty male and female magazine subscription processors working with assigned goals received either specific or general feedback from a computer monitoring system. This feedback was presented to the worker by a supervisor or self-generated by the worker using the computer system. The results produced by the experiment demonstrate that feedback source (self versus supervisor) and specificity (general versus specific) were directly related to performance. In addition, the results of the study showed task planning mediated the effect of feedback specificity on performance; trust in the feedback predicted an individual's level of performance. The findings are presented by Earley as an elaboration of the role of computer-achieved feedback in an organization. This

experiment has shown that information systems are an effective method of feedback, but no comparison to other methodologies are demonstrated.

Expectancy Theory Model of the Goal Setting and Feedback Process

The possibility of integrating expectancy theory and goal-setting theory via goal commitment has been recognized previously (Dachler and Mobley, 1973; Dossett et al., 1979; Kolb and Boyatzis, 1970; Mento et al., 1980; Oldham, 1975; Steers, 1975). Furthermore, Locke et al. (1981) suggested that the factors that affect goal acceptance fit easily into two major categories, which are the main components of expectancy theory. He then listed variables likely to affect expectations of goal attainment and attractiveness of goal attainment. Hollenbeck and Klein (1987) present a model to expand on this work by suggesting additional variables likely to be associated with either the attractiveness or expectancy of goal attainment, as well as differentiating between situational and personal determinants of attractiveness and expectancy.

As previously shown, Figure 1 presents the Hollenbeck and Klein model of the antecedent factors that enhance the commitment to difficult goals. The antecedents of commitment are broken down first by whether they affect attractiveness of expectancy, and then further delineated by whether they are of a personal or situational nature. Figure 1 also suggests, in line with the formulations of Locke (1968), that the primary consequence of goal commitment is to moderate the relation between goal difficulty and task performance. Under certain conditions,

goal difficulty may generate a main effect. For example, when only difficult goals are established, greater commitment will lead to greater performance (Locke et al., 1984). However, when the entire range of goals are represented in a sample (i.e., easy, moderate, difficult) no such main effect will be in evidence.

Human Implications

Lee's research (1991) presents an analysis of a goal setting questionnaire developed by Locke and Latham (1984). The Locke and Latham measure attempts to assess the core goal attributes of specificity and difficulty, as well as other attributes of the goal setting process (such as perceptions about performance feedback, supervisor support, conflict and stress). The psychometric properties of the measure were examined in the study using respondents from employees of a large, west-coast electronics organization. A principal components analysis conducted by Lee extracted ten meaningful factors and identified a need for additional items. Results of the study generally supported the meaningfulness of the goal setting factors and provided important directions for future research. These factors will be evaluated through a questionnaire within this experiment in an effort to determine the human implications of goal setting and feedback.

Goals are typically assigned to the industrial operator. In most research studies, goals are assigned; seldom are they set participatively with the operator. Often the results in terms of worker performance are in conflict regarding the superiority of participative over assigned goal setting (Latham, 1983; Latham, 1975;

Locke, 1981). Participation in goal setting is believed to have a positive effect on worker satisfaction, although some studies have reported that satisfaction declined in both assigned and participative goal setting conditions (Locke, 1984; 1989).

Model and Hypothesis Development

The model presented in Figure 2 is the quintessence of the current research. These relationships evaluated in this field experiment build on the motivational research within the manufacturing realm and offer tremendous opportunity for practical application within the world manufacturing arena.

All goal setting will be self-set by each work cell. The goals will be set related to the performance measures of labor efficiency measured in hours per piece against standard and total machine utilization measured in hours running against total working hours available. The first relationship to be tested is the goal setting and performance relationship. During the measure of this relationship, all other variables (moderators, mediators and demographic), will be controlled. The moderating variables will be held constant by ensuring that no improvements in ability, participation or support are initiated during the experiment. The same operators will remain constant during the experiment. Task complexity has been reviewed for each group and is constant. Other situational constraints will be minimized within the possible confines of a manufacturing environment, yet minor constraint changes should be equally influential across all cells.

The feedback provided during this experiment will be the individual cell's performance, specifically efficiency, utilization and measurements of loss. The method of feedback will be different for appropriate cells as described in the experimental discussions. Training will be provided to the appropriate cells regarding the performance measures, utilization of the decision support system and aggressive goal setting.

The second relationship to be measured in this experiment is the feedback and goal setting. This relationship has been proven many times in laboratory and survey settings. The important relationship is that a manufacturing team supported with a decision support system will set higher goals of production.

The third relationship being evaluated within this experiment is the feedback (independent variable) and goal attractiveness and goal attainment (dependent variable). During the experiment, measures of personal factors regarding goal attainment and expectancy will be developed to determine if the feedback method improves these factors.

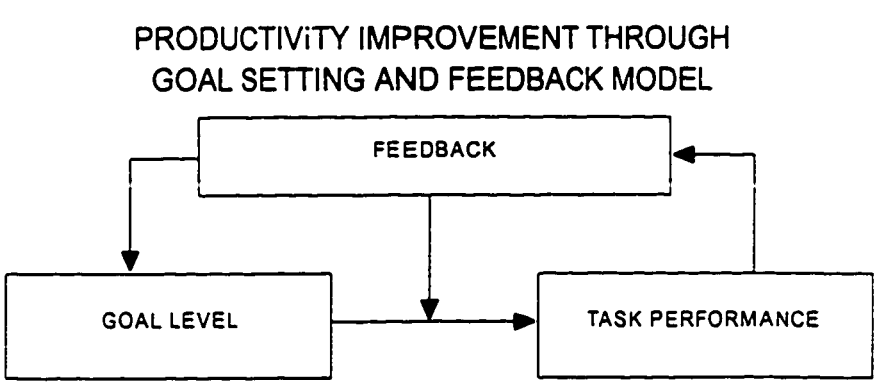

Figure 2

Development of Hypotheses

Information was collected for each product that is produced in these manufacturing cells. This information included the standard time developed by manufacturing engineering for each product. Preliminary observations were made regarding the performance of the manufacturing cells against these standards and this information was established as a baseline for this experiment. Measures of productivity were taken, as well as work sampling studies, to identify the specific opportunities for improvement. The opportunities that are considered under the influence of the operator include set-up time, late start time and extended break time.

The following hypotheses were derived from Figure 2 to determine the productivity improvement effects of goal setting and feedback.

Hypothesis 1: *Employees in a manufacturing work cell utilizing goal setting and given timely feedback on their actual production start time and productivity level will reduce the delay time lost and improve performance compared to employees in a manufacturing work cell not utilizing goal setting or given timely feedback.*

A preliminary study of the work cells in this experiment has indicated that the operators have the ability to start the CNC equipment precisely at the beginning of the shift. These same operators have to contend with interferences that can delay this start. These interferences are quite often under the control of the operators. The measurements of this experiment are testing the hypothesis that the work cells that

get feedback regarding these time losses at the beginning of the shift will actually reduce these losses.

The only feasible way to track and compute this information and provide presentable feedback in a timely manner is through the utilization of an information system. For this reason, only the cells utilizing the information system will be provided this specific feedback.

Hypothesis 2: *Employees in a manufacturing work cell utilizing goal setting and given timely feedback on the duration of their actual break time and productivity level will reduce the production time losses and improve performance compared to employees in a manufacturing work cell not utilizing goal setting or given timely feedback.*

The preliminary study of the work cells in this experiment has indicated that the operators have the ability to start the CNC equipment precisely at the end of scheduled breaks. These scheduled breaks include two ten minute breaks and one thirty minute lunch break. These same operators have to contend with interferences that can delay these startups. These interferences are quite often under the control of the operators. The measurements of this experiment are testing the hypothesis that the work cells that get feedback regarding these time losses at the end of breaks or lunch will actually reduce these losses.

The only feasible way to track and compute this information and provide

presentable feedback in a timely manner is through the utilization of an information system. For this reason, only the cells utilizing the information system will be provided this specific feedback.

Hypothesis 3: *Employees in a manufacturing work cell utilizing goal setting and given timely feedback on the actual duration of changeover time and productivity level will reduce the changeover time and improve performance compared to employees in a manufacturing work cell not utilizing goal setting or given timely feedback.*

The preliminary study of the work cells in this experiment has indicated that the operators perform their own change-overs during the shift for scheduled product changes. These change-overs occur one to three times daily and are scheduled to take approximately 30 minutes. These same operators have to contend with interferences that can delay these changeovers. These interferences are quite often under the control of the operators. The measurements of this experiment are testing the hypothesis that the work cells that get feedback regarding these time losses due to changeovers actually reduce these losses.

The only feasible way to track and compute this information and provide presentable feedback in a timely manner is through the utilization of an information system. For this reason, only the cells utilizing the information system will be provided this specific feedback.

Hypothesis 4: *Employees in a manufacturing work cell given timely feedback and goal setting on their actual production efficiency will improve their efficiency over time.*

As a result of the operators in the two groups of experimental cells receiving the intervention, they are expected to control the interferences within their operation and under their control to improve production efficiency. Essentially, the two cells which receive the intervention will improve their performance against standard, i.e. pieces per shift. The measurements of this experiment are testing the hypothesis that the two work groups that get feedback regarding their overall productivity will actually improve their efficiency and machine utilization over time through goal setting.

Hypothesis 5: *Employees in a manufacturing work cell given a decision support system to facilitate goal setting and providing timely feedback on actual production efficiency will establish more challenging goals than a group provided the same information through a manual system and provided similar support.*

Each of the intervention groups will establish weekly goals of performance which will be measured and computed daily. The first intervention group will manually track their daily production and compute their measure of performance at the end of the shift. The operator will post this information daily on a public work

performance board. This group will also set a goal for the week which will also be posted on the same board. These goals will be self-set with the only intervention being encouragement to set higher goals than the previous week's performance. The desired amount of improvement over the previous week's performance (i.e. the goal) will be determined by the team.

The second intervention group will utilize an on-line time computer system to measure productivity. The operators will enter the product being produced and the quantity produced at the end of each run. The system will track information on a real-time basis and provide instantaneous feedback regarding performance against standard, as well as time losses during the shift. This information will be printed out on a hard copy at the end of each shift for public display. This group will also set a goal for the week which will also be entered into the computer system and performance will be measured against the goal. These goals will be self-set with the only intervention being encouragement to set higher goals than the previous week's performance. The desired amount of improvement over the previous week's performance (i.e. the goal) will be determined by the team.

The measurements of this experiment are testing the hypothesis that the work cells that get feedback regarding their overall performance through the information system will establish more challenging goals than the intervention group utilizing the manual system.

Hypothesis 6: *A decision support system facilitating goal setting and feedback on actual production performance is a more effective tool than traditional supervision intervention leading the goal setting and feedback effort.*

Each of the two intervention groups will be establishing self-set goals on a weekly basis. Since the intervention group utilizing the information system will have more information regarding production losses, it is anticipated that this group will analyze this data and predict specific opportunities to improve. Identifying these specific opportunities, it is further anticipated that this group will perform better. The measurements of this experiment are testing the hypothesis that the work cells that get feedback regarding their overall performance through the information system will perform better (more production against standard) than the intervention group utilizing the manual system.

CHAPTER 3
RESEARCH METHODOLOGY

Direct labor productivity has been shown to improve through the use of goal setting and feedback regarding performance. In this vein, a field experiment was designed to test and measure this improvement over a two month period in a manufacturing setting. This involved initial studies to determine a baseline of performance, implementation of changes to three manufacturing cells for a six week period and some training of supervisors and staff. All of the data collection, training and implementation was performed by the researcher.

Subjects

This study was performed in a traditional manufacturing plant in Western Michigan. The plant employs 310 direct labor people and produces wood frames for the furniture industry. The manufacturing cells are identical in process capability and are contrived of stand-alone CNC machining centers which produce 150 similar product variations. Each cell produces any of the frames depending on the current schedule requirements. Individual operators work in each of the three cells across three shifts. This production make-up allowed us to hold one group as a control group and introduce interventions into the other two. The three shift operation

allowed us to run three equal experiments simultaneously.

Each manufacturing cell was assigned with one individual to run the total operation. With three cells operating on three shifts, the total number of individuals assigned to this experiment was nine. These individuals will be referred from here on as the team members. These team members consisted of eight males and one female. The average age of the team members was 28.7 years with the range being from 19 years to 38 years. The seniority within this company ranged from one year to nine years for the team members and the average was 3.6 years. The duration of comparable work experience ranged from one to nine years. The duration of specific experience that each team member had working within this type of process prior to this experiment was 2.9 years. This duration of experience ranged from eight months to nine years.

Although all of the experimental groups were essentially the same, the three resulting groups were the *control group* which received no intervention, the *supervisory group* received goal setting and feedback facilitated by the supervisor and a public tracking board of daily performance, and the *information systems group* received goal setting and feedback facilitated by an on-line decision support system controlled by the individual cell members.

Study Design

This study utilized three CNC manufacturing cells. These three cells were labeled A, B and C and observations were made on each of three shifts resulting in nine cells total. To ensure no experimental biases due to the cells selected for intervention, Cell A was the control group on the first shift, the information systems intervention group on second shift, and the supervisory intervention group on the third shift. Cells B and C followed the same plan.

Figure 3 summarizes the group breakdowns for this experiment. A total of nine groups were evaluated with pre-test and post-test data collection. The first set of three groups was the control group with all production procedures (mediating and moderating variables) held constant, as well as the feedback of appropriate performance measures. This group did not set goals of performance during the experiment. (This was the current method of production.) The second and third sets of three groups had goal setting and feedback introduced as an intervention to improve performance. Figure 3 depicts the experimental design used.

EXPERIMENTAL GROUP BREAKDOWNS

FEEDBACK

GOAL SETTING

SHIFT	CELL A	CELL B	CELL C
1	CONTROL	SUPERVISOR FEEDBACK SELF-SET GOALS	INFORMATION SYSTEM SELF FEEDBACK SELF-SET GOALS
2	INFORMATION SYSTEM SELF FEEDBACK SELF-SET GOALS	CONTROL	SUPERVISOR FEEDBACK SELF-SET GOALS
3	SUPERVISOR FEEDBACK SELF-SET GOALS	INFORMATION SYSTEM SELF FEEDBACK SELF-SET GOALS	CONTROL

Figure 3

The first group defined was the "Control" group. No intervention regarding additional feedback, goal setting or training other than what they have been getting prior to the experiment was provided to this group during the entire experiment. The control groups were Cell A shift one, Cell B shift two, and Cell C shift three.

The "Supervisor Feedback" intervention utilized traditional manual techniques of tabulating performance and posting results for the team. Within-group knowledge of results was allowed but not between the different intervention or control groups. The measures of feedback included total up-time and total performance against standard. This team received initial training regarding how to compute the productivity measurements and how to post the information on the

board. These intervention groups included Cell A shift three, Cell B shift one and Cell C shift two.

The "Information Systems Technology" intervention groups were provided on-line feedback regarding performance. This feedback involved user interaction to enter information regarding pieces completed, as well as identify when set-ups, breaks and lunch periods were started and ended. The system utilized the computer's internal clock to track these times and computed the productivity performance. The computer also tabulated goal-setting performance. This also enhanced the goal setting effort through more timely feedback and evaluation of goal setting improvement levels. The information system was on the shop floor and utilized by the workers. Training was provided during the initial stages of implementation to ensure operator proficiency utilizing the system. These intervention groups included Cell A shift two, Cell B shift three and Cell C shift one.

Procedure

The first group served as the control group for the entire experiment period. An eight month history of production information was collected for all groups from the end of last year through July of this year. The second group received two months of the designed supervisor and self-directed feedback treatment during August and September. A summary of the information boards supplied to the supervisory intervention groups are presented in Exhibit 1 and Exhibit 2. The information system group received on-line feedback and daily goal setting encouragement through a

customized information system also for the months of August and September.

The "Supervisory Feedback" intervention group received traditional feedback and goal setting through the supervisor. The supervisor was trained and scripted to provide daily feedback regarding the performance of the previous day's work. This feedback was given during the first few minutes of each shift. The supervisors also directed (but did not dictate) the weekly goal setting sessions during this same morning meeting. The supervisor's role was to facilitate the data and present the results to the cell.

In the "Information Systems Feedback" method of intervention, the supervisor's feedback intervention was replaced with an on-line information system. This PC based system provided feedback to the operator at any time during the shift. The operator entered his or her own performance data with measurements being immediate. The system directed goal setting by evaluating goals on level of improvement. This system was totally operator controlled. Specific training regarding the systems use was provided during the initial phase of this experiment.

Measures

The measures of performance were Labor Efficiency (pieces per shift), Set-up and Changeover Time, Down Time and Interference Time. Each manufacturing cell measured performance against standard based on the number of units produced and the time available for production. This information indicated that little variance among cells existed regarding performance against standard. The dependent

variables in this experiment were production up time and pieces produced against standard. The production for each of these nine cells was interchangeable and the measures of performance were consistently measured in the following format: PROD x STD = EH, where PROD equals the number of pieces produced, STD equals the standard hours per piece allowed, and EH equals the earned hours.

The total production for each product (PROD) was summarized at the end of the shift and a total number of earned hours (EH) was calculated using the standard hours (STD). This number of earned hours was divided by the number of hours available (typically 8.0) for the shift and the ratio was the daily productivity for the shift (i.e. 6.0 hours earned divided by 8.0 hours available resulted in a 75.0% efficiency for the shift). The total production had always been tracked on a daily basis by shift and machine. However, the calculations of productivity were through a mainframe MRP system and feedback and summary results were calculated and presented monthly. Therefore, the daily production sheets for a six month history of performance for these cells were gathered and daily productivity was measured as a baseline for each of the cells in this experiment.

The results indicated no difference among cells across the three shifts during the baseline performance period. The control group in each of three cases did not change significantly following the intervention period. The goal setting with supervisory assistance cells improved significantly during the intervention period. The goal setting facilitated by information systems cells each improved significantly and more than the supervisory assisted cells. Each of these scenarios will be

discussed in detail in the following sections.

Data Analysis

Following the intervention period, all of the data was summarized and analyzed to determine if a significant improvement in productivity was achieved. ANOVA was used to determine if significant variance between groups was identified. Furthermore, the procedures and implementation difficulties were noted and documented for the final research report.

Addressing Experimental Guidelines for Success

The guidelines presented by Locke and Latham were considered critical for experimental success within this experiment. Each of the guidelines addressing experimental success was addressed within this experiment as follows.

1. *Organizational support is required.* Top management has been involved with the implementation of this experiment and have agreed to support the training, implementation, measurements, control and feedback for all three groups. The management team understood the importance of sound scientific experimentation, and was motivated by the prospect of tremendous potential benefits. In addition, three key supervisors, one per shift, assisted with the experiment implementation and have established confidence within all of the experimental groups. This experiment was presented as a program of continuous improvement promoted by the company.

2. *A control group must be included within the field experiment research.* There were three control groups, one per shift. This control group was carefully isolated to ensure it remained independent. The control group received the same intervention after the experimental period to bring productivity for all groups to the same level.

3. *Goals must be meaningful and be perceived to be meaningful.* All goals were explained in traditional production measurement as well as dollar amounts. The presentation of dollar values for production loss, inefficiencies, set-up, etc. ensured that all goals for improvement were meaningful.

4. *Goals should be achievable in a short time frame.* All goal setting and feedback were daily for intervention group two and on-line for intervention group three. The formal review time horizon was no more than weekly. Training also ensured that the goals and feedback were provided in a timely manner according to the operators definition.

5. *The measurement of the task needs to be reliable (i.e., stable).* All measurements were against engineered standards that had been recently verified by a professional engineer. This process was ongoing to ensure that standards and measurements were both reliable and understandable.

6. *The response shift phenomenon must be addressed.* Although the control groups did not have access to the same intervention data, explanations were given concerning the reasons for experiments and assurance that their group would be brought on board after the experimental period was completed.

7. *The goal set should be difficult, but attainable rather than impossible.* All goals were self-set but driven towards the achievement of 100% productivity against sound engineered standards. Baseline data showed performance to be approximately 56% of standard. This assured both opportunity and goal difficulty.

8. *The emphasis should be on maximizing performance rather than attaining a goal.* Each goal set was presented with the understanding that future goals would be used to further improve with the ultimate goal as maximizing performance.

9. *The experimenter needs to be present during data collection.* The researcher had been actively involved with the experimental site for over seven years and the teams were anticipating a very positive program for the intervention period.

10. *The information will be made public.* This was a fundamental premise of the experiment; however, the two groups did receive feedback differently. The first group received public information presented on a board, while the second group received public information presented through a computer.

11. *Ensure that the employees have the skills for the job level/complexity.* Pre-measurement ensured that each individual had the ability to attain the goal. Training regarding the information system, feedback, specific measurements, etc. was a necessary pre-experiment activity.

12. *A primary value of goal setting is that it focuses attention.* The goals set were specific; for example, one goal was a specific number of assemblies to complete. Measurement included pieces completed, as well as production time lost which reduced this production from standard.

The next section presents the results of the control groups after intervention, the experimental groups after intervention, and a comparison of the results between the different intervention groups.

CHAPTER 4
RESULTS AND DISCUSSION

The intent of this research was to develop a model of efficient and implementable goal setting and feedback for manufacturing to improve productivity. The contribution of this research must serve numerous requirements. First of all, this research must be consistent with Latham and Locke's (1981) moderator formulation. Second, the antecedents of feedback and goal setting methods used in this research must be consistent with the expectancy theory model for this stream of research presented by Hollenbeck and Klein (1987). Third, the utilization of information technology must be shown to be a viable option of information feedback and a benefactor of the goal-setting process.

Effectiveness and efficiency were used to make an overall assessment of the independent variable which was the productivity measurement and improvement system process. The independent variable had three levels of treatment - baseline, feedback plus goal setting directed by the supervisor, and feedback plus goal setting directed through a shop floor decision support system. The research questions and hypotheses for this study were presented earlier. These hypotheses will be repeated, and the results pertinent to each one will be discussed.

Baseline Data Results

A six-month history of performance was collected for each of the nine cells in this experiment. The following table summarizes the baseline performance for each production cell.

BASELINE PRODUCTION SUMMARY
BEFORE TREATMENT

SHIFT	GROUP	MEAN PRODUCTIVITY (%)	STANDARD DEVIATION (%)
1	CONTROL	55.1%	9.2%
1	SUPERVISOR - GS/FB	56.8%	11.2%
1	INFO SYS - GS/FB	54.9%	11.7%
2	CONTROL	56.1%	7.9%
2	SUPERVISOR - GS/FB	56.2%	9.4%
2	INFO SYS - GS/FB	55.5%	7.1%
3	CONTROL	55.3%	12.1%
3	SUPERVISOR - GS/FB	54.9%	12.2%
3	INFO SYS - GS/FB	54.3%	11.1%
	TOTAL AVERAGE	**55.5%**	10.2%

Table 1

As indicated, the average productivity rate was 55.5% daily. The variance between shifts was primarily due to the level of experience and support that cell received. Each cell's performance was compared to the control group's performance on that shift. ANOVA was performed to ensure each group of comparison was the same. This analysis provided $F_{.05}$

values of .43, .17 and .39. The performance was not significantly different between each shift within a .05 level of confidence. The following ANOVA tables indicate the equivalency of the groups at the beginning of the study.

COMPARISON OF BASELINE GROUP'S
ANOVA TABLES

ANOVA Table - Shift 1

VARIATION	D O F	MEAN SQ	F
0.010149	2	0.005075	0.430002
1.593155	135	0.011801	
1.603304	137		

ANOVA Table - Shift 2

VARIATION	D O F	MEAN SQ	F
0.00236	2	0.00118	0.172377
0.862371	126	0.006844	
0.864731	128		

ANOVA Table - Shift 3

VARIATION	D O F	MEAN SQ	F
0.011156	2	0.005578	0.390867
2.09773	147	0.01427	
2.108886	149		

Table 2

Intervention Data Results - Control Group

All of the performances were summarized following the experimental period. A summary of the control group's performance is as follows in Table 3.

CONTROL GROUP'S PRODUCTIVITY

SHIFT	GROUP	MEAN BEFORE INTERVENTION (% productivity)	MEAN AFTER INTERVENTION (% productivity)	DIFFERENCE
1	CELL A	54.8%	55.1%	0.3%
2	CELL B	55.4%	54.6%	-0.8%
3	CELL C	56.8%	52.1%	-4.7%
SUB TOTAL AVERAGE		**55.7%**	**53.9%**	**-1.7%**

Table 3

As indicated, the average performance after the intervention was 53.9%. Each cell's performance was compared to the control group's performance on that shift. ANOVA was performed to evaluate if any significant difference before and after intervention could be determined. This analysis was completed for each of the three groups individually. This analysis provided $F_{.05}$ values of .15, .09 and 1.19. The performance is not significantly different within each shift at a .05 level of confidence. This established that each control group's productivity did not significantly change during the experimental period. The following ANOVA tables present these findings.'

COMPARISON OF BASELINE GROUP'S PRODUCTIVITY TO CONTROL GROUP'S PRODUCTIVITY ANOVA TABLES

ANOVA Table - Shift 1 Control Group

VARIATION	D O F	MEAN SQ	*F*
0.001752	1	0.001752	0.153844
0.592083	52	0.011386	
0.593834	53		

ANOVA Table - Shift 2 Control Group

VARIATION	D O F	MEAN SQ	*F*
0.000768	1	0.000768	0.093817
0.425926	52	0.008191	
0.426695	53		

ANOVA Table - Shift 3 Control Group

VARIATION	D O F	MEAN SQ	*F*
0.013339	1	0.013339	1.190014
0.582882	52	0.011209	
0.596221	53		

Table 4

Intervention Data Results - Supervisory Goal Setting and Feedback

All of the performances were summarized following the experimental period. A summary of the supervisory intervention group's performance was as follows.

SUPERVISORY INTERVENTION GROUP'S PRODUCTIVITY

SHIFT	GROUP	MEAN BEFORE INTERVENTION (% productivity)	MEAN AFTER INTERVENTION (% productivity)	DIFFERENCE
1	CELL A	55.8%	60.9%	5.1%
2	CELL B	56.1%	61.3%	5.2%
3	CELL C	57.2%	61.3%	4.1%
	SUB TOTAL AVERAGE	**56.4%**	**61.2%**	**4.8%**

Table 5

As indicated, the average performance after the intervention was 61.2% for these groups. Each cell's performance was compared to the control group's performance on that shift. ANOVA was performed to evaluate if any significant difference before and after intervention could be determined. This analysis was completed for each of the three groups individually. This analysis provided $F_{.05}$ values of 1.64, 4.46 and 2.05. Although the performance of each of the three groups had improved over the intervention period, only the second shift group had improved significantly within a .05 level of confidence. The conclusions made from this analysis were that the supervisory directed methodology for goal setting and feedback improved the productivity for one of the three manufacturing cells. A longer period of performance would be required before the other two cells would be considered to be improved significantly. The resulting ANOVA tables are as follows.

COMPARISON OF BASELINE GROUP'S PRODUCTIVITY TO SUPERVISORY GROUPS PRODUCTIVITY ANOVA TABLES

ANOVA Table - Shift 1 Supervisor Group

VARIATION	D O F	MEAN SQ	F
0.021709	1	0.021709	1.641116
0.687873	52	0.013228	
0.709583	53		

ANOVA Table - Shift 2 Supervisor Group

VARIATION	D O F	MEAN SQ	F
0.023047	1	0.023047	4.463632 *
0.268492	52	0.005163	
0.29154	53		

ANOVA Table - Shift 3 Supervisor Grou

VARIATION	D O F	MEAN SQ	F
0.019086	1	0.019086	2.058811
0.482084	52	0.00927	
0.50115	53		

*p<.05

Table 6

Intervention Data Results - Automated Goal Setting and Feedback

All of the performances were summarized following the experimental period. A summary of the information systems intervention group's performance is as follows.

INFORMATION SYSTEMS INTERVENTION GROUP'S PRODUCTIVITY

SHIFT	GROUP	MEAN BEFORE INTERVENTION (% productivity)	MEAN AFTER INTERVENTION (% productivity)	DIFFERENCE
1	CELL A	55.2%	66.2%	11.0%
2	CELL B	55.9%	64.6%	8.7%
3	CELL C	57.8%	67.0%	9.2%
	SUB TOTAL AVERAGE	**56.3%**	**65.9%**	**9.6%**

Table 7

As indicated, the average performance after the intervention was 65.9% for these groups. Each cell's performance was compared to the control group's performance on that shift. ANOVA was performed to evaluate if any significant difference before and after intervention could be determined. This analysis was completed for each of the three groups individually. This analysis provided $F_{.05}$ values of 4.18, 10.86 and 8.14. The performance of each of the three groups has improved over the intervention period significantly within a .05 level of confidence. The conclusions made from this analysis are that the information systems directed methodology for goal setting and feedback improved the productivity for all of the three manufacturing cells. The resulting ANOVA tables are as follows.

COMPARISON OF BASELINE GROUP'S PRODUCTIVITY TO INFORMATION SYSTEMS GROUP'S PRODUCTIVITY ANOVA TABLES

ANOVA Table - Shift 1 Info Syst Group

VARIATION	D O F	MEAN SQ	F
0.053737	1	0.053737	4.180968 *
0.681199	53	0.012853	
0.734936	54		

ANOVA Table - Shift 2 Info Syst Group

VARIATION	D O F	MEAN SQ	F
0.051352	1	0.051352	10.86733 **
0.24572	52	0.004725	
0.297072	53		

ANOVA Table - Shift 3 Info Syst Group

VARIATION	D O F	MEAN SQ	F
0.077127	1	0.077127	8.147681 **
0.492236	52	0.009466	
0.569363	53		

*p<.05, **p<.01 Table 8

Intervention Data Results - Supervisory versus Automated

All of the performances for each of the intervention groups were summarized and compared following the experimental period. A summary of the supervisory improvement versus the information systems group's improvement is presented in Table 9.

SUPERVISORY GROUP'S PRODUCTIVITY vs.
INFORMATION SYSTEMS GROUP'S PRODUCTIVITY

SHIFT	GROUP	SUPERV GROUP MEAN CHANGE (% productivity)	INFO SYS GROUP MEAN CHANGE (% productivity)	AVERAGE VARIANCE
1	CELL A	60.9%	66.2%	5.3%
2	CELL B	61.3%	64.6%	3.3%
3	CELL C	61.3%	67.0%	5.7%
	SUB TOTAL AVERAGE	61.2%	65.9%	4.8%

Table 9

As indicated, the average performance of the information systems group was 4.8% better improvement than the supervisory groups. ANOVA was performed to evaluate if any significant difference between groups could be determined. This analysis was completed for each of the three groups individually. This analysis provided $F_{.05}$ values of 4.93, 6.94 and 3.94. Although the performance of each of the six groups had improved over the intervention period, this analysis showed clearly that information systems supported goal setting and feedback was a superior method. This was shown within a .05 level of confidence. The resulting ANOVA tables are as follows.

COMPARISON OF SUPERVISORY INTERVENTION GROUP'S PRODUCTIVITY TO INFORMATION SYSTEMS GROUP'S PRODUCTIVITY ANOVA TABLES

ANOVA Table - Shift 1 Info vs Supervisor

VARIATION	D O F	MEAN SQ	F
0.043161	1	0.043161	4.931426 *
0.122531	14	0.008752	
0.165691	15		

ANOVA Table - Shift 2 Info vs Supervisor

VARIATION	D O F	MEAN SQ	F
0.033653	1	0.033653	6.940963 *
0.06303	13	0.004848	
0.096682	14		

ANOVA Table - Shift 3 Info vs Supervisor

VARIATION	D O F	MEAN SQ	F
0.010099	1	0.010099	4.743327 *
0.033294	13	0.002561	
0.043393	14		

* p<.05

Table 10

Analysis of Hypotheses

Each of the hypotheses prepared in the design section of this research will be evaluated individually. This research has shown that significant productivity improvement was achieved during this experiment. Hypotheses 1, 2, and 3 addressed the potential reasons for the productivity improvement within the individual intervention cells. Since only the experimental groups tracked these specific delays electronically, they were the only groups used to calculate significant improvement for these hypotheses.

Hypothesis 4 compared the level of productivity and the level of goal setting for the intervention cells with the control group. Hypotheses 5 and 6 compared the productivity level between the two sets of intervention groups.

Hypothesis 1: *Employees in a manufacturing work cell utilizing goal setting and given timely feedback on their actual production start time and productivity level will reduce the delay time lost and improve performance compared to employees in a manufacturing work cell not utilizing goal setting or given timely feedback.*

A preliminary study of the work cells in this experiment has indicated that the operators have the ability to start the CNC equipment precisely at the beginning of the shift. These same operators have to contend with interferences that can delay this start. These interferences are quite often under the control of the operators. The measurements within this experiment tested the hypothesis that the work cells that get feedback regarding these time losses at the beginning of the shift will actually reduce these losses.

The only feasible way to track and compute this information and provide presentable feedback in a timely manner was through the utilization of an information system. For this reason, only the cells utilizing the information system were provided this specific feedback and measured for this hypothesis.

The results indicated that these cells did not significantly improve their production start time delays significantly. The first two weeks of data collection and feedback regarding this time were averaging 12.2, 14.2 and 11.0 minutes of delay per day at the beginning of the shift respectively for the three information systems intervention groups (these groups combined were 12.2 minutes of lost time per day). The last two weeks of data collection and feedback regarding this time were averaging 12.4, 14.5 and 9.01 minutes of delay per day at the beginning of the shift respectively for the three information systems intervention

groups (these groups combined were 12.1 minutes per day). This change was not significant. Therefore, Hypothesis 1 is not supported.

> **Hypothesis 2:** *Employees in a manufacturing work cell utilizing goal setting and given timely feedback on the duration of their actual break time and productivity level will reduce the production time losses and improve performance compared to employees in a manufacturing work cell not utilizing goal setting or given timely feedback.*

The preliminary study of the work cells in this experiment has indicated that the operators have the ability to start the CNC equipment precisely at the end of scheduled breaks. These scheduled breaks include two ten minute breaks and one thirty minute lunch break. These same operators have to contend with interferences that can delay these startups. These interferences are quite often under the control of the operators. The measurements of this experiment are testing the hypothesis that the work cells that get feedback regarding these time losses at the end of breaks or lunch will actually reduce these losses.

The only feasible way to track and compute this information and provide presentable feedback in a timely manner is through the utilization of an information system. For this reason again, only the cells utilizing the information system were provided this specific feedback and measures for this hypothesis.

The results indicated that these cells did not significantly improve their production break time delays significantly. The first two weeks of data collection and feedback regarding this time were averaging 8.2, 14.4 and 12.0 minutes of delay per day at the

beginning of the shift respectively for the three information systems intervention groups (these groups combined were 11.6 minutes of delay time per day). The last two weeks of data collection and feedback regarding this time were averaging 10.4, 14.5 and 9.1 minutes of delay per day at the beginning of the shift respectively for the three information systems intervention groups (These groups combined were 11.1 minutes of delay time per day). This change was not significant. Therefore, Hypothesis 2 is not supported.

> **Hypothesis 3:** *Employees in a manufacturing work cell utilizing goal setting and given timely feedback on the actual duration of changeover time and productivity level will reduce the changeover time and improve performance compared to employees in a manufacturing work cell not utilizing goal setting or given timely feedback.*

The preliminary study of the work cells in this experiment has indicated that the operators perform their own change-overs during the shift for scheduled product changes. These change-overs occur one to three times daily and are scheduled to take approximately 30 minutes. These same operators have to contend with interferences that can delay these changeovers. These interferences are under the control of the operators. The measurements of this experiment are testing the hypothesis that the work cells that get feedback regarding these time losses due to changeovers actually reduce these losses.

The only feasible way to track and compute this information and provide presentable feedback in a timely manner is through the utilization of an information system. For this reason, only the cells utilizing the information system were provided this specific feedback.

The results indicated that these cells did significantly improve their production change-over time delays significantly. The first two weeks of data collection and feedback regarding this time were averaging 120.2, 118.2 and 111.5 minutes of delay per day at the beginning of the shift respectively for the three information systems intervention groups (these groups combined were 117.2 minutes of set-up time per day). The last two weeks of data collection and feedback regarding this time were averaging 96.4, 114.5 and 99.2 minutes of delay per day at the beginning of the shift respectively for the three information systems intervention groups (These groups combined were 102.1 minutes of set-up time per day). This change was significant at $p<.05$. Therefore, Hypothesis 3 is supported.

Hypothesis 4: *Employees in a manufacturing work cell given timely feedback and goal setting on their actual production efficiency will improve their efficiency over time.*

As a result of the operators in the two cells receiving the intervention, they were expected to control the interferences within their operation that were under their control and ultimately to improve production efficiency. Essentially, the two cell groups which received the intervention should improve their performance against standard. The measurements of this experiment were testing the hypothesis that the two work cell groups that get feedback regarding their performance would improve their performance.

As previously indicated, the average performance after the intervention was 61.2% for the supervisory groups and 65.9% for the information systems groups. Each cell's performance was compared to the control group's performance on that shift. ANOVA was

performed to evaluate if any significant difference before and after intervention could be determined. This analysis was completed for each of the three groups individually. This analysis provided $F_{.05}$ values of 4.46 and 2.05 for the supervisory groups and 4.18, 10.86 and 8.14 for the information systems groups. The performance of each of the six groups had improved over the intervention period but only four had improved significantly within a .05 level of confidence. The conclusion made from this analysis is that the information systems directed methodology for goal setting and feedback improved the productivity for all of the three manufacturing cells. Based on this analysis, Hypothesis 4 is supported.

> **Hypothesis 5:** *Employees in a manufacturing work cell given a decision support system to facilitate goal setting and providing timely feedback on actual production efficiency will establish more challenging goals than a group provided the same information through a manual system and provided similar support.*

Each of the intervention groups established weekly goals of performance. The supervisory intervention groups established the same goal for the entire eight week period. This goal was 75% productivity. This goal did not change over the experimental period. The information systems groups established goals of 80%, 85% and 85% respectively for each shift. These goals also did not change over the eight weeks of intervention. Although the information systems group did not change over the period of intervention, the goals were higher than the supervisory goals; therefore, Hypothesis 5 is supported.

Hypothesis 6: *A decision support system facilitating goal setting and feedback on actual production performance is a more effective tool than traditional supervision intervention leading the goal setting and feedback effort.*

The measurements of this experiment were testing the hypothesis that the work cells that got feedback regarding their overall performance through the information system would perform better (more production against standard) than the intervention group utilizing the manual system.

As previously indicated, the average performance of the information systems group was 4.8% better improvement than the supervisory groups. ANOVA was performed to evaluate if any significant difference between groups could be determined. This analysis was completed for each of the three groups individually. This analysis provided $F_{.05}$ values of 4.93, 6.94 and 3.94. Although the performance of each of the six groups had improved over the intervention period, this analysis shows clearly that information systems supported goal setting and feedback is a superior method. This is shown within a .05 level of confidence and, therefore, hypothesis 6 is supported.

CHAPTER 5
SUMMARY

The research question was *"To what extent can a manufacturing work cell utilizing an information system, which enhances goal setting and provides specific performance feedback to the employees, improve productivity?"*

The results of the present study demonstrate the efficacy of a daily adjusted goal setting and feedback procedure for improving the performance, efficiency and job satisfaction of production employees in a furniture manufacturing company. Most importantly, this study revealed that an information system, facilitating goal setting and feedback, can provide the critical role as catalyst to the goal setting and feedback phenomena and can play an important role in improving individual performance levels.

For each cell receiving the goal setting and feedback intervention, the total earned hours increased quickly (within one week) over the past six months of production tracking prior to the intervention. Furthermore, performance improvements were immediate when the independent variable was added and were sustained over time following the intervention. Pre-treatment baselines remained relatively stable except when the independent variable was added. This indicates that the goal setting and feedback intervention were responsible for noted improvements in performance.

The findings of the present study are consistent with reports in the literature which show that feedback alone is effective, but more effective with the addition of goal setting (Balcazar et al, 1985). Furthermore, these results demonstrated that a daily-adjusted goal setting and feedback intervention was effective at improving the performance levels of manufacturing personnel working in a cellular manufacturing situation.

Unlike many other goal setting and feedback programs, this intervention offers a means of measuring and tracking performance, as well as assessing the accuracy of self reports of that performance across a variety of tasks. In this context, the measurement process in this study was critical. This strategy helped to maintain quality within a program designed primarily to increase quantity of output.

The type of work performed by the people in this experiment is noteworthy. The tasks completed by these people are considerably more complex than the majority of assembly and manual machining duties throughout the rest of the plant. In addition, the autonomy that these individuals received is somewhat unique since these are essentially one man operations. Future research should address differences in outcomes across complex and simple tasks when feedback systems are used. This view is supported by O'Hara, Johnson, and Beehr (1985) who noted that most Organizational Behavior Management interventions have dealt with simple rather than complex behaviors since observing and quantifying such behaviors are relatively easy. They also suggest that more attention to complex tasks is needed.

Because employees self-recorded their performance during the baseline condition, the possibility exists that those measures were, in fact, inflated. Self-recorded feedback

serves as a mechanism of delivering feedback, since employees are generating their own feedback through their self-recorded performance (Komaki et al., 1980; Wilk & Redmon, 1990). However, it is clear that significant performance improvements occurred for all subjects with the introduction of the supervisor goal setting and verbal feedback phase leading to the conclusion that the effects of the self-recorded feedback were relatively minimal.

Even though feedback and goal setting have been shown to be effective in changing performance, some specific types of feedback appear to enhance the improvements more than others. In the present study, the data indicated that graphic feedback display combined with goal setting was more effective than verbal feedback combined with goal setting. Furthermore, these improvements were maintained and were consistent across individuals and sections of the organization. This finding is in agreement with other research which has shown graphic feedback to be superior to other types (Balcazar et al., 1986).

One possible reason for improvements noted during the verbal feedback plus graphic feedback phase is the value of the information being provided to the employees. With graphic feedback, employees can more closely monitor their individual performance levels and adjust it precisely to improve output; the relationship between behavior change and change in the numerical data on the visual display provides a more precise and sensitive indicator of performance than verbal descriptors. Prue and Fairbank (1981) noted that graphic feedback provides a product that allows a longitudinal assessment of the performance. It may simply be the case that graphic feedback increases the usefulness of the information presented since precise comparisons with earlier performance levels are possible.

Gilbert (1978) noted that "when working on independent tasks, improvement requires confirmation of one's present position so that necessary alterations can be made"(p. 53). Clearly, graphic feedback provides such performance data.

Fairbank and Prue (1982) also noted that verbal feedback interventions must take into account the social/interpersonal skills of the individuals delivering the feedback and the past history of interpersonal interactions between the providers and the recipients. Therefore, with the utilization of graphic feedback in conjunction with goals and verbal feedback, the emphasis on the social and verbal skills of the supervisor may be less than that of a purely verbal feedback interaction. Furthermore, task completion might better come under control of the actual performance data, as opposed to the verbal statements of a supervisor.

The job satisfaction data from the survey indicated that employees were more positive about the work environment in general following the goal setting and feedback program than prior to the use of the intervention. Significant positive changes were noted in the area of participation and involvement. With the addition of a goal setting program, as well as daily feedback on performance, it would be expected that employees would report having a clearer understanding of their daily job expectations and duties. Similar changes were noted in supervisor support. Since supervisors were required to meet with employees on a daily basis and engage in a positive performance-related interaction with them at least once a day, it is not surprising that employees reported greater supervisor support under this program as opposed to less defined and irregular management systems.

Komaki et al. (1978) noted that changes in worker behavior can be initiated and maintained without reliance upon the use of disciplinary procedures. Furthermore, a

program such as this one was clearly designed with the intent of helping motivate employees to maximize their performance levels. For example, based on previous performance, daily goals were set for the following day. Generally, the goals were determined by looking at goal attainments during the previous day(s), and stabilizing there or increasing slightly toward the upper end of the employees' performance criteria. Thus, because the goal would be sustained until performance either stabilized or exceeded that level, employees had the opportunity to earn additional praise for performance improvements on a regular basis. Furthermore, goal setting by a supervisor allows employees to focus their performance and work towards a specific goal (Kim & Hammer, 1976; Latham & Baldes, 1975; Latham & Kinne, 1974).

Other more general factors involved in the present study were critical to success. One aspect of this study that proved to be a strong mechanism in gaining initial support and interest in the program was the self-recording performance data sheets. Employees were initially very hesitant to cooperate with the researcher; however, by instituting the data sheets prior to any intervention, the employees were eased into the program gradually and had the opportunity to ask questions and understand what this program entailed. Self-recording provided a mechanism by which the employees became involved in the day to day data keeping of a program. Furthermore, they could monitor their own performances and budget their time accordingly. Particularly for repetitious, process work, self-recording provides an excellent content to be used with other forms of performance feedback.

In spite of overall positive outcomes, several shortcomings in this study should be noted. First, the time frame for the intervention was limited to two months. A longer data

collection period could ensure the longevity of the conclusions of this analysis.

Second, all subjects received verbal feedback followed by the addition of graphic feedback. Therefore, sequence effects cannot be ruled out and it is not known if the results would have been altered if graphic feedback plus goal setting were provided before the verbal feedback plus goal setting phase. A component analysis is needed to assess the relative contributions of these intervention elements in different sequences.

A third weakness was the inability to generalize the conclusions of this research. Unfortunately, again, the applied nature of this research made this impossible. However, the positive results are consistent with previous research and offer tremendous opportunity and incentive for further research.

Consistent with other researchers's conclusions (Balcazar et al., 1985-86; Fellner and Sulzer-Azaroff, 1984; Kim, 1984; Komaki et al., 1978; Wilk & Redmon, 1990), performance feedback clearly offers manufacturers a powerful tool for motivating employees. In addition, an information system provided to a manufacturing work team has been shown to offer a practical means for implementation. It is critical, however, that the elements of effective feedback be examined so that the critical aspects of it are better understood and may be most effectively utilized. The present study represents a step in that direction.

Productivity is a major area of concern for all manufacturers in this globally competitive market. Productivity improvement through people is the most likely method for achieving competitive cost advantage (Longenecker, Stansfield and Dwyer, 1997). Goal setting and feedback are a proven method of improving productivity through people. Tools that offer managers assistance in the difficult task of implementing these concepts are of

tremendous value. Therefore, this scientific research has clearly shown that information systems support to a self directed work team can be a key component to this competitive advantage effort.

The purpose of this study was to support the previous research that goal setting and feedback work. This has been clearly shown. Second, the purpose of this study was to evaluate varied methods of implementation and determine which is most effective. Clearly from the results, the decision support system was the superior method of implementation. The primary reason for this is the structure that the information system offers. Supervisors and production people who are continually responding to their changing environment cannot add to their towering workload unless it is an activity that is viewed as valuable, interesting, clearly defined and not time consuming. Goal setting and feedback address the value issues, and the decision support system offers the interest, definition and time savings.

This research is based on a field experiment in a competitive manufacturing environment. This test bed offers credence to the results, as well as addresses the "real-life" issues facing manufacturing. The results of a field experiment are not generalizable across different environments, industries or types of manufacturing. But this situation could certainly be viewed as a typical manufacturing situation involving machinery, people and traditional working parameters. Therefore, the value of this research to academics and practitioners alike is exceptional.

The significant reason for improvement was through the operator's ability to improve the change-over time. This was shown in hypothesis three to be significant for the information systems group. It also should be noted that the information systems group was

given feedback pertaining to lost change-over time that could only be calculated and tabulated through a computer system. Therefore, the computer system was the significant element to improving productivity significantly within this field experiment.

These findings answer the call from Ilgen for more feedback studies in manufacturing research. They also support the research questions proposed by Locke and Latham regarding which methods of feedback are most effective. And finally, this research addresses a weakness of past research in that it was based strictly on literature or laboratory experiments.

The practical applications for this research include additional experimental studies in varied manufacturing cells to further support these findings and examine the generalizablity of the results. The results of this experiment included a ten percent increase in average productivity after this intervention and this should certainly interest any practitioner. A refined script and decision support system should offer tremendous commercial potential.

In conclusion, if an employer feels it has employees that require achievement, job involvement and organizational commitment, goal setting and feedback offer tremendous opportunities to improve the productivity of the operation and the morale in the organizational climate. Employee morale and motivation were both improved in this field experiment. Most importantly for the stockholders, productivity and ultimately profits were improved.

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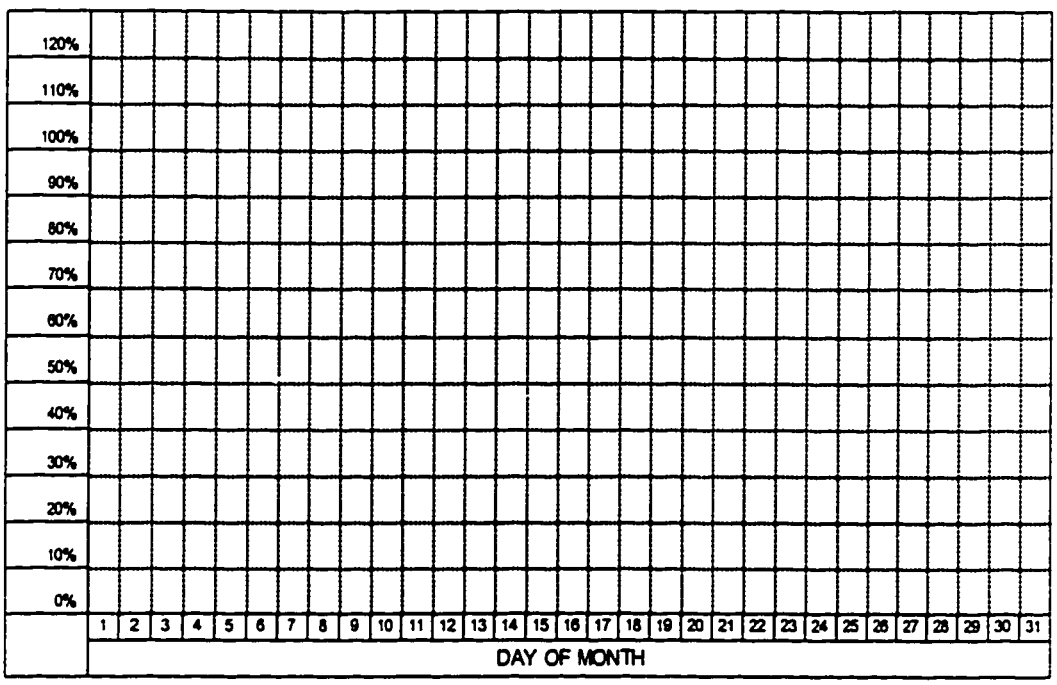
EXHIBIT 1

PRODUCTIVITY MEASUREMENT BOARD
CNC MACHINING

MONTH OF: _____

PRODUCTIVITY
MEASUREMENT



1ST SHIFT IN BLACK
2ND SHIFT IN GREEN
3RD SHIFT IN BLUE
GOAL IN RED

EXHIBIT 2

PRODUCTIVITY MEASUREMENT BOARD

TODAY'S DATE: _____

TODAY'S GOALS ARE:

FIRST SHIFT PRODUCTION	SECOND SHIFT PRODUCTION	THIRD SHIFT PRODUCTION
____ CHAIRS PER HOUR	____ CHAIRS PER HOUR	____ CHAIRS PER HOUR
____ CHAIRS PER SHIFT	____ CHAIRS PER SHIFT	____ CHAIRS PER SHIFT
____ CHAIRS PER WEEK	____ CHAIRS PER WEEK	____ CHAIRS PER WEEK

PRODUCTION HOUR	FIRST SHIFT	FIRST SHIFT (%)	COMMENTS	SECOND SHIFT	SECOND SHIFT (%)	COMMENTS	THIRD SHIFT	THIRD SHIFT (%)	COMMENTS
1									
2									
3									
4									
5									
6									
7									
8									
TOTALS									

DAY OF WEEK	FIRST SHIFT CUMULATIVE PERFORMANCE			SECOND SHIFT CUMULATIVE PERFORMANCE			THIRD SHIFT CUMULATIVE PERFORMANCE		
MONDAY									
TUESDAY									
WEDNESDAY									
THURSDAY									
FRIDAY									
SATURDAY									
SUNDAY									
WEEKLY TOTAL									