

FEEDBACK AND GOAL SETTING TO IMPROVE MANUFACTURING

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ABSTRACT

To be a world-class competitor, discrete part manufacturers can utilize feedback and goal setting to improve productivity and manufacturing performance. This research involves a field experiment in furniture manufacturing and tests two methods of goal setting and feedback on productivity improvement. 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. The results of this research have shown that goal setting and feedback can significantly improve employees motivation and productivity.

INTRODUCTION

The contemporary manufacturer is working in a globally competitive environment. Four avenues of competition have been identified including cost, quality, service and innovation. 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.

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.

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 this research.

GOAL SETTING AND FEEDBACK

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.

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 (1984) 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.

Experimental Design

All goal setting was self-set by each work cell. The goals were 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), were controlled.

The feedback provided during this experiment was 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 was provided to the appropriate cells regarding the performance measures, utilization of the decision support system and aggressive goal setting.

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.

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.

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.

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. The information system group received on-line feedback and daily goal setting encouragement through a customized information system also for two months.

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: $PROD \times STD = EH$, where PROD equals the number of pieces produced, STD equals the standard hours per piece allowed, and EH equals the earned hours.

RESULTS

The intent of this research was to develop a model of efficient and implementable goal setting and feedback for manufacturing to improve productivity.

Baseline Data Results

A six-month history of performance was collected for each of the nine cells in this experiment and 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.

Intervention Data Results - Control Group

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.

Intervention Data Results - Supervisory Goal Setting and Feedback

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.

Intervention Data Results - Automated Goal Setting and Feedback

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.

Intervention Data Results - Supervisory versus Automated

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.

SUMMARY

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.

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.

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.

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.

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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