Estimating the benefits of a quality circle intervention

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Introduction

Recently, American organizations have been implementing quality circles at a rapid rate. Paradoxically, such implementation decisions are generally not based upon evidence regarding the effectiveness of these interventions. In part, this result derives from the contradictory needs of researchers and practitioners. Whereas the former have traditionally emphasized the use of statistical tests of differences among treated and control groups to illustrate an intervention's effectiveness, practitioners assess the value of these interventions based upon projected dollar returns or savings. One technique, referred to as utility analysis (Landy, Farr and Jacobs, 1982; Schmidt, Hunter and Pearlman, 1982), integrates both concerns to demonstrate the dollar impact of an intervention's productivity effect size. Such a procedure allows decision-makers to assess the likelihood that their organization will obtain financial value from implementing a quality circle. The present study (as part of an ongoing evaluation of a quality circle intervention) illustrates application of the utility procedure and demonstrates how the results enable managers to make a rational appraisal of the impact expected from implementing a quality circle intervention.

Quality circles

Quality circles are viewed by many organizations as one way to get the employee to participate at work. Through regular meetings, a small group of five to 10 voluntary employees and their supervisor, who receive training in problem analysis and statistical techniques, identify and propose solutions to work-related problems. These proposals are then presented to management, who retains the responsibility to accept, modify, or reject the quality circle proposals (Lawler and Mohrman, 1985; Thompson, 1982). In this fashion, employees are able to participate in decisions that affect their work, while management retains the authority for decision-making.

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The quality circle literature suggests that employee participation in solving job-related quality problems and improving methods of production will benefit the organization directly, by improving quality and productivity, and indirectly, through enhanced employee motivation and more favorable attitudes (Barrick and Alexander, 1987). This study restricts its analysis to those benefits which derive from productivity-related outcomes and does not attempt to evaluate a quality circles impact upon employee attitudes or the solutions themselves (which may result in improved quality or operating cost reductions). Thus, this study is primarily concerned with establishing the financial value of any productivity gains resulting from a quality circle intervention.

Decision-theoretic utility equation

Organizational decision-makers, who are interested in the company’s survival, are primarily concerned with the economic value of employee responses to an intervention. Researchers, in contrast, typically emphasize the use of statistical tests of group differences to evaluate the intervention’s usefulness rather than assess the financial value of these differences. Interestingly, the decision-theoretic utility equation is able to incorporate both approaches since it translates the value of any group differences attributed to the intervention into units (generally dollars) which decision-makers can incorporate in their evaluations. Thus, through utility analysis an organization can assess the extent to which employee performance is affected by the intervention as well as determine the dollar value of those changes.

Traditionally, the utility equation provided an estimate of the level of utility or expected monetary value obtained by the organization for implementing the quality circle (Schmidt et al., 1982). However, it should be noted that the utility equation can clarify, through a relatively simple transformation, the level of employee performance that would be necessary for a proposed intervention’s benefits to exceed its costs. That is, utility analysis can also be used to specify the amount of increased performance required for the intervention to exceed its break-even point (Boudreau, 1984).

As the utility literature suggests, there are a number of critical factors that must be acknowledged in order to accurately assess the expected utility of an organizational intervention. One critical component is an index of the efficiency of the program. For selection purposes, the correlation coefficient between the predictor (i.e. selection test ‘scores’) and criterion (i.e. job performance ‘scores’) reflects this index of efficiency. For other organizational interventions a better index of any improved employee performance derived from implementing the intervention is a productivity effect size. This measure depicts the standardized difference in job performance between the average person in the ‘experimental’ group (quality circle participants in this study) and average person in the ‘control’ group (nonparticipants in this study), and this effect size \(d_i\) is expressed as:

$$d_i = \frac{\text{mean}_{\text{experimental\,gp}} - \text{mean}_{\text{control\,gp}}}{\text{standard deviation (pooled within gp)}}$$  \hspace{1cm} (1)

When performance has not been reliably measured (e.g. when performance is based on judgments) the effect size \(d_i\) estimate should be corrected for unreliability. Therefore, to determine the true value of these performance differences, equation 1 is corrected for scale unreliability (i.e. \(d_i/\sqrt{r_{xx}}\)) or \(((\bar{X}_{\text{experimental\,gp}} - \bar{X}_{\text{control\,gp}})/\text{SD pooled gps})/\sqrt{r_{xx}}\). As this suggests, the effect size \(d_i\) parameter represents the standardized difference in job performance between the average participant and nonparticipant in a quality circle.
The second component of the utility equation assesses the dollar value of the variability in productivity among employees. As previously illustrated, the index of efficiency reports productivity gains in standard deviation units. Therefore, to assess the economic implications of these performance differences (in standardized form), one must obtain an estimate of the dollar value of one standard deviation of job performance (i.e. SD\text{y}). Assuming these differences are normally distributed, the difference between the value of the products and services provided by an average employee and those provided by an employee at the 85th percentile (one whose performance is as good or better than 85 percent of the employees) is equal to SD\text{y}. By generating an estimate of the value of these performance differences in standard deviation units (SD\text{y}) it is possible to translate the productivity increases identified by the index of efficiency (in standardized form) into dollars. Although this component has traditionally been the most difficult to estimate, recent innovations have resulted in the development of a number of procedures (Boudreau, in press) that provide an estimate of the value of these performance differences.

Other critical components include the number of people that experience the intervention as well as the duration over which the intervention continues to influence employee responses. In addition, an estimate of the utility of an intervention must subtract the total cost of acquiring, administering, and maintaining the intervention. Generally, such costs would include both direct and indirect costs associated with the intervention (e.g. cost of employee's time, trainer's time, facilities, supplies, travel, etc.). Finally, the time value of differentially accumulated costs and benefits must be acknowledged (e.g. through net present value or NPV). Such time-discounting of payoffs minimizes the importance of any errors in a decision-maker’s dollar estimates particularly those based upon uncertain future projections, as well as recognizes the fact that a dollar earned today is more valuable than a dollar earned next year, if for no other reason than the dollar earned today can be invested at prevailing interest rates (Alexander and Barrick, 1987).

By incorporating these various components, the utility equation provides information either depicting the level of overall value attributed to the intervention or clarifies the productivity increases required to exceed breakeven. In the first instance, the procedure provides an estimate of the level of expected utility or the absolute dollar value the intervention is expected to contribute to the organization. To determine this value, the equation is:

\[
U = \frac{(1+i)^T - 1}{i(1+i)^T} [(Ns)(\text{SD\text{y}})(d_i)] - \frac{(1+i)^T - 1}{i(1+i)^T} [(C_o + C_1)]
\]

where \(U\) = the expected utility or dollar value of an intervention, such as a quality circle, to the organization; \(T\) = the average number of years that job performance increases due to implementing the intervention; \(Ns\) = the number of quality circle participants; \(\text{SD\text{y}}\) = the value of one standard deviation of job performance reported in dollars; \(d_i\) = the effect size, expressed as a standardized difference in job performance between quality circle participants and nonparticipants; \(i\) = the cost of capital; \(C_o\) = the original costs incurred in developing the quality circle intervention; and \(C_1\) = all costs associated with maintaining the intervention. (A more detailed explanation of these parameters and their assumptions are provided by Boudreau (in press) and Schmidt, Hunter, McKenzie and Muldrow (1979).)

Although an overall utility estimate (i.e. expected dollar value) of an intervention is generally preferred, the utility equation may be utilized simply to clarify the extent employee performance and productivity must increase in order to offset the costs incurred in implementing the intervention. Such an analysis is particularly useful in the absence of specific performance data, as occurs when forecasting the value of implementing a proposed intervention (e.g. a quality circle). Under such circumstances, a key component of the utility equation (the productivity effect
size \(d_i\) is unknown. However, by assigning a zero (which represents the intervention’s break-even point between the expected benefits and its costs) to the expected utility estimate \(U\) and solving for the known parameters, one can establish the value the missing productivity effect size parameter must exceed in order for the intervention’s benefits to exceed its costs. To solve for the known parameters, a simple transformation of equation 2 results in:

\[
d_i = U - \frac{\left[ \frac{(1+i)^T - 1}{i(1+i)} (C_o + C_i) \right]}{\left[ \frac{(1+i)^T - 1}{i(1+i)} (N_s)(S_D^2) \right]}
\]

or

\[
d_i = 0 - \frac{\left[ \frac{(1+i)^T - 1}{i(1+i)} (C_o + C_i) \right]}{\left[ \frac{(1+i)^T - 1}{i(1+i)} (N_s)(S_D^2) \right]}
\]

where \(d_i\) is unknown and all other terms are known \((U = \text{zero, the interventions break-even value})\). This procedure, referred to as break-even analysis (Boudreau, 1984), provides an effect-size estimate \(d_i\) that serves as a benchmark against which the practitioner can assess the likelihood that the intervention will benefit the organization financially. Such an evaluation may simply be based upon intuition developed from experience or comprise a more extensive literature-based conclusion.

In summary, this study is not an attempt to develop or validate a theory about quality circles. Rather, the primary purpose is to demonstrate the value of determining the overall expected value of the quality circle intervention or determine the likelihood that the intervention will exceed its break-even value by applying a linear decision-theoretic utility equation. To our knowledge, no previous research has incorporated a utility analysis in quantifying the expected value of a quality circle intervention to an organization.

**Application of the method**

**Procedure**

In this study, a large national bank headquartered in a Midwestern city implemented a quality circle program. A consulting group with considerable experience in designing such programs was invited to implement a standard quality circle program for clerical employees from three separate, but comparable, clerical departments. Over the course of this study, a total of five quality circles were implemented in one of these departments. This provided a unique opportunity since the other two departments (with comparable jobs) were not involved in the intervention and therefore served as 'control groups'. It should be noted that the actual evaluations upon which this study are based were conducted by individuals who were not associated with either the organization or the consulting firm, thus it was expected that they would mitigate the potential for bias (particularly demand bias) in the outcomes, and would not have a vested interest in the results.

In this study, 30 of 113 clerical employees voluntarily participated in the quality circles program...
during the first year. Most participants were female high school graduates over 35 years of age and were permanent employees working full time. Initially, quality circle participants received training for the first 10 weeks of meetings.

The objective of training was to introduce the participants to the quality circle process, and to familiarize them with techniques to identify and quantify work-related problems. Among the techniques used to identify and propose solutions to job-related problems were brainstorming, cause and effect diagrams, pareto analysis, histograms, and checklists. The training also included how to make effective management presentations. It should be noted that each quality circle leader was given additional training in group process. After training, participants followed standard quality circle procedures. They met once a week and selected problems to address. Finally, they periodically presented proposals to a management committee who retained the responsibility to accept, modify, or reject the quality circle proposal.

During the first year, six proposals were presented by the five quality circle groups and accepted by the management committee. Generally the work group was responsible for implementing the solutions, but in all cases implementation occurred relatively soon after proposal acceptance. The problem areas investigated by these circles were very similar to those generally reported in the literature, including equipment design, processing efficiency, work area layout, and improved communications. In essence, the circles carried out a very general mandate to identify and solve problems. Interviews seemed to reflect general satisfaction with the quality circle process although some disappointment was expressed regarding top management rules restricting the types of problems that the circles could address.

Measures

To assess the overall expected utility (i.e. derived from equation 2) and to estimate the productivity effect size value necessary for the benefits to exceed costs (i.e., derived from equation 3), all known parameters were assessed, where: (\( N_s \)) represents the 30 quality circle participants in this study and the intervention is applied for only one year \( (T) \); \( (SD_y) \) is $6365, based upon the 40 percent of mean salary rule suggested by Schmidt et al. (1982); \(^2\) the effect size \( (d) \) was estimated at 0.60, by applying equation 1 to the organizational measures available; 0.10 was the cost of capital \( (i) \) to the firm; and development costs are $6677 for \( (C_d) \) and $41650 for annual maintenance costs \( (C_m) \). Cost estimates are based upon actual expenditures during the start-up and implementation period. All other parameter estimates were based upon information provided by the organization's personnel department.

Some comment is required regarding two of these parameters. First, the one year \( (T) \) value was adopted in this study to provide a more conservative estimate of the intervention's utility. Second, in this study the organization did not collect information on employee performance which is the measure generally used to estimate the productivity effect size parameter \( (d) \). However, the organization did gather data depicting other organizational outcomes (i.e. turn-

\(^2\) The Schmidt et al. (1982) procedure employs a 'proportional' rule of mean salary (i.e. 40 percent to 70 percent) as an estimate of SD\(_y\). That is, SD\(_y\) is conservatively estimated as 40 percent of average salary. Recent evidence (Hunter, Schmidt and Judiesch, 1990) supports the proportional rule by demonstrating that the standard deviation of output across employees ranges from 40 percent to 60 percent to 100 percent of mean salary as one moves from low which corresponds to those used in this study), to medium to high complexity jobs. It should be noted, however, that a number of different procedures for estimating SD\(_y\) have recently been developed (the interested reader is referred to a review of these methods (Boudreau, in press) for an in-depth discussion regarding the application and computation of these procedures). This SD\(_y\) method was selected because its results generally correspond with the results from other methods (Boudreau, in press), it is the simplest procedure to apply and because it was not possible to use other methods.
over, absenteeism and overtime). Although these measures are not employee performance measures, for purposes of illustration, the average effect size from these three measures was utilized in this study as a proxy of the productivity effect size estimate. That is, the 0.60 effect size \((d_i)\) reflected the average difference between participants and nonparticipants on these measures.

This provides all of the information needed to calculate the various utility values. For equation 2, recall that \(d_i\) is represented by a term which proxies employee performance. Solving equation 2 with this effect size estimate yielded an overall expected utility of $60,281 for one year. However, given the uncertainty associated with the appropriateness of this effect size \((d_i)\) estimate, a break-even utility analysis (see equation 3) was conducted to ascertain the unmeasured productivity effect size \((d_i)\) required for the intervention’s benefits to exceed any implementation and maintenance costs. The resulting standardized effect size \((d_i)\) of 0.25 is substantially less than the average effect size of 0.60 previously assumed in this study (based on available organizational outcomes). Taken together, these results suggest that the quality circle intervention’s benefits very likely will exceed its associated costs and thereby provides information regarding the probability of obtaining financial value (rather than the probability of obtaining a statistically significant result) from implementing this quality circle program.

**Discussion**

Since 1980, business publications and management journals have published accounts claiming savings to cost ratios as high as 6 to 1 for quality circle interventions. Typically, these estimates are based on the results of improvement projects rather than on productivity gains linked to the work performance of circle members. The present study, however, estimated the potential dollar gains from a quality circle intervention based upon the extent to which productivity, as measured by a standardized effect size, must increase to counteract the implementation and maintenance costs incurred by implementing this quality circle intervention. The reported dollar value of $60,281 (from equation 2) reflected the value the organization had already obtained in increased performance from the five quality circles implemented during the first year.

Although this utility estimate indicates that the quality circle intervention would financially benefit the organization, there was some concern about the accuracy of the productivity effect size \((d_i)\) these results were based upon. First, since the quality circle participants are volunteers, the observed effects may simply be attributed to a Hawthorne effect or a self-selection effect. Although this alternative explanation cannot be ruled out, there were no significant pretest differences between quality circle participants and nonparticipants. A second concern addresses the sample size. Given the relatively small number of employees affected by the intervention in this study \((N=30)\), the resulting performance distributions may not be normally distributed, as assumed. Further, the organizational measures (i.e. turnover, absenteeism, and overtime), may not depict the group’s actual productivity effect size \((d_i)\). To address the latter two concerns, a break-even analysis (i.e. equation 3) was conducted to determine the effect size \((d_i)\) required for the quality circle benefits to exceed its costs.

The resulting standardized effect size \((d_i)\) of 0.25 was substantially less than the 0.60 effect size derived from the non-productivity based estimate provided by the organization. In addition, this estimate is significantly less than the combined average effect size of 0.44 (standard deviation =0.025) reported in a recent meta-analysis of psychologically-based intervention programs (Guzzo, Jette and Katzell, 1985). In addition, the 0.25 effect size necessary to break-even in this study is 3.86 standard deviations below the 1.11 effect size recently reported for a quality
circle program implemented in a manufacturing firm (Marks, Mirvis, Hackett and Grady, 1986). Both studies suggest that there is a 99 per cent probability that the effect size will exceed the 0.25 effect size identified in the break-even analysis. Further, a recent review of the quality circle literature (Barrick and Alexander, 1987) illustrates that studies using productivity indices generally report increased levels of job performance after implementing quality circles. Taken together, these results indicated that the productivity-related effect size of 0.25 required to exceed break-even was realistically obtainable, based upon a comparison of effect sizes reported in this study as well as in the relevant literature. In fact, if the effect size were as large as that reported by Marks et al. (1986) (i.e. $d = 1.11$) the implementation of these five quality circle groups for just one year would be worth $96,689 to the organization.

These utility estimates solely reflect the value of the increased productivity resulting from quality circle participation (where these gains are attributed to the motivational aspects of the intervention). They do not include the monetary value of any quality increases or cost savings which may derive from the suggestions proposed by the quality circles. For example, one idea alone was expected to save the company $1800 per year in labor costs, yet these savings are not reflected in the utility estimates. Further these estimates reflect only one year’s contributions (when start-up costs are dramatically higher). Even though this represents a conservative estimate of the value of the quality circle intervention, the resulting utility estimate (i.e. $60,281) suggests that the benefits obtained during the first year would still exceed the costs incurred in the following year. Taken together, this suggests that the utility values identified in this study are likely to understate the interventions value. Therefore, even though these utility estimates are conservative estimates of the financial value of the intervention, the procedure does provide monetary estimates for organizational decision-makers to consider.

Without some estimate of the monetary value of these interventions, organizations frequently must justify the implementation of quality circles (as well as other employee-involvement processes), simply on the belief ‘they are the thing to do’ As illustrated in this study, a decision-theoretic utility equation is one technique that practitioners can effectively apply to either demonstrate an intervention’s value or to identify the effect size required for the organization to obtain a financial gain from the intervention. By describing the benefits of our interventions (e.g. a quality circle) to organization decision-makers in a metric (i.e. dollars) that they are conversant with, practitioners should be able to increase their acceptance and commitment to those interventions.

References


Marks et al. (1986) reported a $t$ statistic in their study rather than the effect size ($d$) of 1.11 as reported in the present study. Therefore, to convert the $t$ statistic into the effect size reported in this study, the conversion formula suggested by Schmidt et al. (1982) was applied, where the overall productivity $t$ value was 5.39 with a sample size of 46 for both quality circle participants and nonmembers (Marks et al., 1986). Further, applying Hedges (1982) effect size variance equation provided a standard deviation estimate of 0.22 for the overall productivity variable (Marks et al., 1986).

As noted by other researchers (e.g. Marks et al., 1986) the benefits derived from quality circle are relatively dynamic over time. Thus, the average effect size obtained over the first year from both very successful and less successful circles was utilized as a conservative estimate of the value of the quality circle intervention in this study. Of course, to accurately depict the dollar value of a dynamic intervention over an extended period, the cost estimates and effects size parameters utilized in equations 2 and 3 should change over time, based upon annual changes in these parameters over $t$ years.


