
A Six Sigma quality approach to workplace evaluation

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Abstract

This paper reviews post-occupancy evaluation (POE) research methods and discusses how these methods can be deployed within the context of a Six Sigma quality framework. The paper outlines the importance of conducting POEs to support the creation and management of optimal spaces for office workers. The authors review a variety of existing POE approaches and discuss their approach to using POEs as part of an ongoing quality framework. The results of a pilot programme using their approach, and application of these POE and quality tools, are discussed in this paper.

Keywords:

post-occupancy evaluation, Six Sigma, design, office, quality

INTRODUCTION

Post-occupancy evaluation (POE) research methods have existed for decades and have been used with varying degrees of success to provide feedback to the design and management of workspace. Six Sigma quality approach and tools also have existed for many years, but have largely been applied to improving manufacturing processes. An approach to workplace evaluation has been developed which takes POE methods and applies them within the context of a Six Sigma quality framework.

As a case study, this paper describes a POE conducted for a consumer products company in which employees were shifted from a mix of 80 per cent cubicle workstations and 20 per cent private offices to an open design concept using 100 per cent open workstations. Management wanted to increase the quality of those work environments through a series of pilot projects which would provide feedback about the success of the design and permit improvements, prior to a wider rollout of this design strategy. Once the pilots were conducted and the assessment complete, the quality

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processes and measurement tools were left in place to create an ongoing quality programme to track workplace performance.

The team wanted an in-house capability that would put them in control of the evaluation process — and the opportunity for continuous improvement in the work environment — without the constant requirement for outside resources to support the work. The team selected the idTools system, an enterprise survey data analysis application for facility management. The team also began the process of tracking these data, using Minitab, which contains Six Sigma quality tools, such as control charts. The results of the pilot programme and the use and application of these POE and quality tools are discussed in this paper. While the analysis approach taken with this particular project was complex, it is emphasised that the quality tools and steps can also be used in a much simpler form with great success on projects on a day-to-day basis.

Use of POE is key to creating and managing optimal office space

POST-OCCUPANCY EVALUATION

Post-occupancy evaluation tools and methods vary widely in terms of complexity, cost and duration of time to implement. They are key to the creation and management of optimal spaces for office workers. New measurement and analysis tools are now available to permit internal corporate facilities groups to conduct POEs with a level of cost, quality and sophistication that would have been unimaginable a few years ago.

Post-occupancy evaluation has been recognised as a useful workplace design and management tool since the mid-1970s. It has been used in architecture, interior design, ergonomics, facilities management and other fields. The primary focus of the POE in terms of office/work space has been on evaluating the fit of space to human needs. The term itself comes from the occupancy permit issued by a building inspector to certify that a building can be occupied after construction is complete.¹

There are many reasons for conducting a POE. From a strategic perspective, a POE programme can be used to learn from the past in order to improve on future projects. This is especially beneficial when an organisation is involved in a long-term, multi-phased project, where the results of the initial POE can be utilised to fine-tune and improve the design of future phases before they are constructed. Another benefit of POE is as a change communication tool. Workplace evaluations can serve as a platform for enhanced communications between facility managers and the facility users or their representatives.

If the evaluation responses are treated with respect, improved communication and trust will result, even if the specific problems cannot be solved. From the perspective of the facilities or real estate group, such an evaluation shows a commitment toward integrating the opinions and concerns of the end users into the design solution.² Another benefit to the facilities management team

is that the POE process itself can be employed as a marketing tool to their internal customers. It increases the profile of the facilities group with the users of the space, and shows their commitment to funding continuous improvement activities. In addition, involving the end-users in the process will increase their understanding of any changes that result.

Types of post-occupancy evaluation

The type of POE implemented will be influenced by the goals of the workplace project and the sponsor or audience for the results. The metrics (areas of measurement) emphasised by a POE commissioned for a Chief Financial Officer (CFO) or operational lead will be different from that for a lead in organisational development. The project objectives and internal sponsor will influence the measurement methods employed and the sophistication of the analysis required.³

Type of POE is influenced by project goals and audience for the information

By definition, all true POEs have several common characteristics, including some sort of data collection before and after a change in the environment. The pre-change data are used to establish a 'baseline' for comparison. Next, using the same methods employed in the 'pre' phase, data are collected after the change to the work environment. Some type of analysis to compare these 'pre' and 'post' data is then conducted to draw inferences about any differences found in the results between the before and after versions of the work environment. Any structured POE project is a form of workplace research.

The differences in POEs are mainly involved with the research design of the comparison, the types and amount of data collected, and the tools and methods used to analyse the data.⁴ Table 1 shows the various options for designing a POE, including the research design and data collection methodologies and the types of analysis.

RESEARCH DESIGN

Case study

Designers and facility managers use case studies to describe and diagnose a single project, workspace or building. The POE is used to observe the changes made to the work environment, and to understand the impact of this specific setting and workspace on behavioural, financial, work process or other outcomes. A case

Table 1: Typical POE study design options

Research design	Data collection	Analysis
Case study	Questionnaire	Qualitative/descriptive
Field study	Physical traces	Quantitative
	Interview/focus group	
	Single point in time/longitudinal	

study is appropriate when the team is interested mainly in information related just to the particular project and is not trying to generalise the findings too far outside the context of that project or business.

A case study may use multiple research techniques, such as observations of physical traces (papers and work materials on desks or in meeting rooms) mapping or tracking of employee locations within the workspace, structured interviews, questionnaires or even testing of mock-ups of potential workspaces (see Table 1).

Field study/quasi-experiment

A field study design (or ‘quasi-experimental design’)^{5,6} is useful when investigators want to find out in detail about a phenomenon, such as ‘collaboration’ or about a type of work environment/work, such as ‘call centres’. Field studies generally use a prepost design, sometimes with a ‘control group’ of participants who did not receive any change to the work environment. The number of participants in these studies tends to be larger, and thus data are frequently collected through questionnaires. Questionnaire data are suitable for quantitative analysis and manipulation through statistical analysis software.

POE method is limited because data is not collected over time

Depending on the rigour of the design and quality of the survey tools employed, the data collected can support a wide range of analyses, which tend to be primarily quantitative (Table 1). Analyses of the quantitative data can render relatively simple conclusions, such as identifying changes in employee perceptions after the change to the workspace, or powerful interpretations, such as identifying specific design features that influenced specific behaviours (collaboration), and supporting the assertion that the redesign of the workspace, and not other outside factors, predicted the behavioural change or other outcome.

The primary limitation to a field study POE is the limit to generalisation of the findings to other settings and populations. The term generalisation refers to the extent to which the findings and implications of the results of a study can be confidently applied to other work environments and populations. Factors such as sample size, size of the population being studied, and quality of the questions asked determines this limit. Powerful survey tools can lower the cost of conducting larger scale surveys and help to increase the generalisability of the results and interpretation. Greater generalisability is especially beneficial to POEs that are conducted within one part of a business organisation, where the intent is to generalise the findings to influence the design of spaces for similar classes of work or business processes in other parts of the company.

Possibly the biggest limitation, however, is actually one of process; that is, POEs are generally viewed as a single ‘event’, and little thought is given to collecting data over time (for instance to track the stability of the effects of the new environment on behaviour or to gain ongoing feedback from participants) or to the

integration of the findings into an ongoing process for continuous improvement. This is why the integration of POE methods into an ongoing quality framework is of such importance.

POST-OCCUPANCY EVALUATION MEASUREMENT METHODS AND THE SIX SIGMA PROCESS

Post-occupancy evaluation measurement methods were used as the core of a Six Sigma quality approach to the ongoing implementation and continuous improvement of work environments. While a comprehensive discussion of the entire Six Sigma approach is beyond the scope of this paper, a central component of the approach is the ongoing measurement of workplace performance and the creation of a feedback loop to guide strategic design development of the space.

In the measurement approach, two related terms were used: 'metrics' and 'measures'. Metrics are the 'what' that is measured, and measures are the 'how' something is measured. A 'metric' (or Key Performance Indicator) is an overall area of measurement, such as 'customer satisfaction' or 'comfort' or any other higher-level construct. 'Measures' are the specific types of measures that are employed to 'tap in' to that construct. For instance, the metric for 'comfort' could be measured by four or five individual questions related to seating comfort and other ergonomic issues. The methods used to gather data could include a questionnaire, observations or other sources.

Because Six Sigma is rooted in improving manufacturing processes, not all aspects of this approach neatly fit the needs of facility design and management. The key principles of Six Sigma of identifying key performance metrics, collecting and analysing data on an ongoing basis, and the use of those data as a management tool for continuous improvement of work environments, however, remain central to the present approach.

The Six Sigma process

Six Sigma is an approach to improving the quality of products or services, which strives for near perfection. It is a disciplined, data-driven approach and methodology for eliminating defects in any process — and thus the product of that process.⁶ A Six Sigma defect is defined as anything outside customer specifications. Six Sigma tools can be used to describe how well a process (or product, such as a work environment) is performing — and indicate ways of improving that process. To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities.

Measurement and statistical analysis of data are central to the Six Sigma approach. The focus of Six Sigma is to reduce the variation in quality measures over time. The overall Six Sigma process is used to take the results of measures, interpret their meaning and determine improvements to be made to the product or process based on this feedback.

DMAIC—define,
measure, analyse,
improve, control

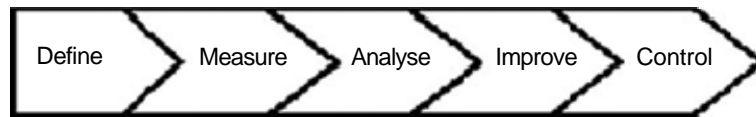


Figure 1 DMAIC approach

There are many variations on this entire ‘measurement–feedback loop’ process. One commonly used Six Sigma process is called DMAIC (define, measure, analyse, improve, control), which is typically used to improve existing processes (see Figure 1). The DMAIC approach is used in the ongoing evaluation of workspace, because it is a powerful process to improve the fit between customer requirements for the space and the performance of that space. Requirements for the space are determined by the organisation and can include metrics as diverse as behavioural (such as collaboration) to more traditional financial measures (such as churn costs). Thus, the measures can be related to strategic business outcomes as well as immediate tactical concerns such as reducing the costs of managing the space.

Briefly, the DMAIC phases include the following activities: in the define phase, the project is scoped and measures established; in the measure phase, initial measures are collected; in the analyse phase, the data are analysed and further measures taken; in the improve phase, strategies are implemented to make improvements; and in the control phase, the findings are shared organisationally, and a measurement–feedback loop is established to collect data, identify problems and ‘hold the gains’ — make continuous improvements. In this paper, this DMAIC approach is applied to an organisation which wanted to align its office facilities more closely with its business mission and future direction.

CASE STUDY

This corporation is a widely diversified leader in the consumer products industry. A household name, their business strategy requires innovation by promoting behaviours such as collaboration, communication, group work and mobility. To support that strategy, they intended to create flexible spaces that support the desired behaviours, encourage a sense of belonging and communicate corporate image to employees and customers. They felt that their current workplace standards no longer fit their strategy. They implemented a pilot project to test ideas about changing the way workspace is allocated, planned, designed and managed. The pilot programme was viewed as a ‘working lab’ to test the elements of the design strategy and to apply the learning for a new Headquarters building. They also wanted to ensure that the space would support the new ways of working for employees within all job types, from executives to clerical staff.

To provide credible information to support the pilot, a rigorous

POE methodology was implemented within a Six Sigma DMAIC framework.

Define phase

A small Steering Committee was formed, consisting of the VP of Real Estate and Director of Facility Services. The Project Team consisted of members of the consulting team, the (external) design team and several company employees involved in various aspects of the project. The team worked for about a month to create a team charter, which outlined the goals of this project. The team created overall project success metrics, also referred to as 'key performance indicators' (KPIs), based on the strategy articulated by senior management. KPIs are general areas of measurement that are relevant to the broader goals of the organisation. For instance, one KPI for this project was 'Support for Innovation'. The group needed to decide how they would measure this KPI. They decided that three kinds of behaviour would support greater innovation within the organisation, including

KPIs are areas of measurement relevant to the organisation

- employees' sense of belonging to the company
- collaboration
- quality of internal group processes.

These KPIs were developed from review of the business literature and discussions with management. Once finalised, they were reviewed by the Steering Committee. These measures are strategic in nature, because they reflect the company's intention to align the work environment to enhance key behaviours which will, in turn, support the business goal of innovation.

Measure phase

In this phase, the specific measures were finalised which would be used to assess the KPIs (see Table 2). The study itself used a

Table 2: KPI measures

Sense of belonging to the company
<ul style="list-style-type: none">. This office space conveys the appropriate image of the company to employees and others.. The workspace helps team members feel that they are really part of the team through design features or visual cues.. The design of the interior space where my primary workstation is located contributes to my sense of belonging to the organisation.
Collaboration
<ul style="list-style-type: none">. The overall workspace lets me quickly shift from individual work to collaboration with others.. The design of the various spaces in this office provides adequate support for collaboration.
Quality of group process
<ul style="list-style-type: none">. The workspace supports team member participation in the ongoing work.. It is easy physically to access co-workers when we need to discuss a work-related issue.



Figure 2: idTools report screen, showing analysis of pre-move to post move data

Measure phase:
finalise specific
measures

factorial ‘repeated measures’ design with data collected at regular intervals throughout the duration of the study from both experimental and control groups.^{8,9} The study involved 180 employees within two pilot phases. In phase I, employees were moved into a new space designed to enhance performance on the KPIs. In phase II, the design of the pilot spaces were fine-tuned based on feedback after the first phase. The data collection tool was a questionnaire, developed with a series of questions that tapped into each of the three KPIs, as well as other issues related to workplace design performance. This was deployed within the idTools survey analysis system used by the team to collect the data and provide the initial analyses (see Figure 2).

Analysis phase

In this phase, the pre- and post-move data were analysed according to the methods specified for the POE research design, and tracked using Six Sigma statistical process control (SPC) tools. Once the data on KPIs had been collected, a technique known as SPC was employed to analyse the process variation measures on each of the three KPIs. The primary tool of SPC is the control chart, which permits identification of the sources of process variation (discussed in detail in the following section). The control charts used for this project were generated through the MiniTab Statistics software package — an inexpensive and commonly available application.

SPC used to monitor
variability in a
process over time

Statistical process control

Using SPC tools, the variability in a process over time (in this case the quality of a work environment) is monitored by collecting data at regular intervals. Data are displayed and analysed through control charts, which can be used to track results and reveal

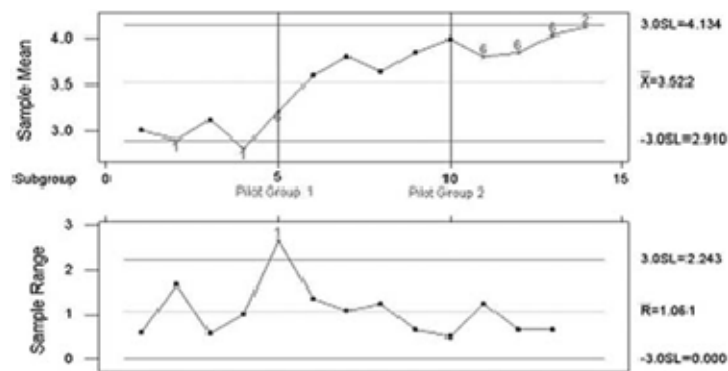


Figure 3: XR Bar Chart showing results for 'Sense of Belonging to the Company'

whether adjustments need to be made to the process (or to the work environment) to reduce the variability and bring the process back 'into control' if needed. Control charts can be used to determine whether process improvement efforts (such as with workplace design) are having the desired effects (see Figure 3).

Variability

Two types of variability can occur in a process (or work environment) that is being tracked: common cause variation or special cause variation.¹⁰ Common cause variation is simply the normal variation about the statistical mean that occurs when data are collected at many points over time. Special cause variation comes from outside events or fundamental problems with the design of the system (or workspace) in terms of meeting employee needs. The project team's goal was twofold: to reduce special cause variation and to increase scores on the KPIs over time. In the case of work environment evaluation, special cause variation would be due to lack of fit between employee needs on the KPIs, and the design or management of the space in support of those needs. Figure 3 shows the results of the project on one KPI, 'Sense of Belonging to the Company'. Owing to space constraints, the focus is on this example to explain fully the aspects of this control chart, and how the data apply to this case study.

The XR Bar Chart is a powerful tool showing process variability and trends, and permits interpretation of data so that changes can be made to the workplace. The X Bar Chart (upper chart, Figure 3) shows the means (averages) of the samples at each observation point over time. The R Chart (sample range, lower chart, Figure 3) shows the variability in the scores from the sample at each observation point. In both charts, the centreline shows the grand mean (average of the averages), about which the scores are plotted. The system calculates boundary lines three sigma limits above and below the centreline. These charts can then be used to determine whether the KPIs are within Six Sigma limits.

In a situation in which one is trying to reduce process variation over time, and increase scores on the KPIs, the desired result is to see an upward trend in scores within the X chart, and a downward trend, or scores that cluster tightly about the 'average' line, for the R chart.

In this study, data were collected every three weeks from a sample of 20 employees in both experimental and control groups.¹¹ Figure 3 indicates that data were collected at 15 points in time over the course of this project. The vertical lines through the X Chart (upper chart, Figure 3, 'Pilot Group 1' and 'Pilot Group 2') show the points at which design changes to the workspaces were implemented.

Root cause analysis identifies possible sources of problems

Root cause analysis

The first five data points show below average scores on the KPI 'Sense of Belonging to the Company' (X Bar Chart, Figure 3). The variance (range) in each of the samples is also relatively high, even becoming 'out of control' at the fifth data collection point (see R Bar Chart, lower part of Figure 3). Thus, scores are low and highly variable, indicating a lack of consistency in the message the work environment conveys to employees about using the work environment as a tool to engender a sense of ownership and belonging.

Improve phase

A root cause analysis was performed in which the possible causes for the performance gaps were generated by the project team, and a list of the 'vital few' causes were selected. Data collected prior to the change were used in part to inform the root cause analysis. The goal was to reduce the problems with the workplace design. The primary changes to the design focused on creating areas in the space to enhance team identity, as well as providing visual cues through colour and signage to reinforce membership with the business unit and the organisation.

In this phase, the solutions selected should be evaluated on scale of potential impact, as well as cost considerations. If the solution(s) is costly and time consuming, the team should consider using small-scale pilots to test the efficacy of the proposed solutions with employees. Once the solution has been selected and piloted, a solution implementation plan should be established which would include a project schedule, resources, budget and communication plan.

After approximately 100 employees were moved to the new space, the data collection continued at regular intervals from both the experimental and control groups (indicated by the vertical line above 'Pilot Group 1', data collection points 510, Figure 3). The XR Bar Charts reveal a significant improvement in employees' sense of identification with the company after this change (see Figure 3). The X Bar Chart shows that KPI scores increased above

the average (indicated by the middle horizontal line) and even above the levels experienced after the first intervention, and stayed above that line consistently for the five data-collection points. The R Bar Chart shows a reduction in the ranges of scores within each data sample during that time period, indicating improved consistency in employees' perceptions of the space. Referring to the sense of belonging created by the new space, one employee said: 'As a result of the open design, I'm more aware of others and of the image my space conveys to others and of those visiting the area.'

Although these initial results were positive, the project team decided to examine the data, combined with observations (walkthroughs) and interviews with people using the new space, to determine whether additional modifications to the space could result in further improvements to the KPI scores. A second root cause analysis was conducted with this information, which yielded further insights into the design. The team found that, while the space contributed to an enhanced feeling of belonging overall, employees within some job categories were actually feeling somewhat alienated by the new space, which was holding down the overall scores and increasing the variability of the measures.

These job types, comprising administrative and support duties, were located somewhat at a distance from the new team spaces, and had high levels of enclosure through panel height. While the original model for the space had equally distributed team members throughout the floor plate, the new model centralised their workspaces and team spaces by job function. Thus, in the new space, the administrative spaces with high enclosure were clustered together. Because of their location and high level of enclosure, these employees felt somewhat disconnected from their teams and perhaps from the company. The project team acted quickly to relocate administrative employees' workspaces closer to the teams they supported, and lower the amount of enclosure in their workspaces.

Once these changes were made, the data collection continued at regular intervals from both the experimental and control groups (indicated by the vertical line above 'Pilot Group 2', data collection points 10–15, Figure 3). The XR Bar Charts reveal a significant improvement in employees' sense of identification with the company after this change (see Figure 3). The X Bar Chart shows that KPI scores increased above the average (centre line) and stayed above that line consistently for the five data-collection points. The R Bar Chart shows a reduction in the ranges of scores within each data sample during that time period, indicating improved consistency in employees' perceptions of the space.

Control phase

Control phase-hold
the gains

Typically, once a facility redesign has been implemented and employees relocated into the new or renovated space, it is usually time to move on to the next project or 'put out the next fire'. Thus,

the opportunity to learn from the completed project and to make ongoing improvements is lost.

The DMAIC approach attempts to 'hold the gains' made through the project, using a control phase. The key components of this phase are the implementation of a monitoring plan, creation of a response plan, transfer of ownership (project closure) and sharing the 'lessons learned' with the organisation.

As part of the monitoring plan, the use of the idTools application (survey and reports from a database) was implemented as part of a permanent feedback loop to gather information on the performance of the work environment. The information collected is a source of data for the control charts, which are used for assessing the ongoing quality of the work environment. The team is using these tools to collect data to track the variance in performance on each of the KPIs over time.

The response plan is a checklist or process by which the facility management team can react to the analysis provided by the control charts when a problem is revealed in one of the performance metrics. In this case, the response plan is a simple set of steps (the root cause analysis) which allows the team to identify and rank any problems and brainstorm design responses as required. In the case of this project, one of the team members on the original project is also on the facilities staff. This member was trained on the use of idTools and Minitab and will 'own' the ongoing data collection/analysis activities within the control phase, as well as communication responsibilities.

Finally, the data being gathered were shared with the organisation through meetings involving leads of the facility management staff and tools including a PowerPoint presentation and a case study. These communication materials focused on best practices and lessons learned and are being considered by another team which is creating standards for use in other parts of the organisation.

SUMMARY

This paper reviewed POE research methods and showed how these methods can be deployed within the context of a Six Sigma quality framework. The case study described a POE conducted for a consumer products company in which employees were being shifted from traditional cubicle workstations to a newer, more open design concept. Among other goals, management wanted to use the design of space as a tool to communicate corporate image and foster a sense of belonging to the organisation by its employees. This was accomplished through a pilot project in which design concepts were developed and refined through feedback from POE and Six Sigma measures, prior to a wider rollout of this design strategy. Once the pilots were conducted and the assessment complete, the processes and tools were left in place to create an ongoing quality programme to track workplace performance against these KPIs.

The team wanted an in-house capability that would put them in control of the evaluation process — and the opportunity for continuous improvement in the work environment — without the constant requirement for outside resources to support the work. The team selected the idTools system, an enterprise survey data analysis application for facility management. The team also began the process of tracking these data using Minitab, which contains Six Sigma quality tools, such as control charts.

LESSONS LEARNED

POE as part of a Six Sigma framework

- This project represents a complex example of a POE as part of a Six Sigma framework. This approach could bear valuable results without the added complexity of a control group and the additional required statistical analyses. The simple survey data collection methods (idTools) and the Minitab Control Charts would be adequate to perform the analyses and interpretation. For those facility managers seriously interested in conducting a POE within a Six Sigma framework, it is recommended that they seek formal Six Sigma training.
- It is emphasised that it is better to conduct some type of POE evaluation, rather than doing nothing at all. With the variety of web-based tools available today, the ability to issue and tabulate a POE is far easier and less time consuming than ever before. The information received can have a significant impact on the facilities management planning for the future, as well as validate the efforts of facility managers truly to understand how daily decisions affect future facilities performance.
- It was also found that, to increase the buy-in and ultimate success of such a programme, communication about the programme scope and benefits to all sponsors and participants is critical. It is suggested that spending time up-front to create a 'story' about the project, activities and potential (strategic and financial) benefits, links to other quality initiatives. This story should be communicated in the months prior to beginning the project. Set up a steering committee to sponsor and guide the project. If it is difficult to engage management participation in a steering committee, there might be something lacking in the story one is trying to tell or in articulating the benefits of the project.
- Apply the 'so what' test to each KPI. When formulating the KPIs for the project, think carefully about how each metric would ultimately be applied to justify a change in the design of the space or facility management process used to support the space. If the link between a KPI and specific actions cannot easily be seen, reconsider the use of the KPI.
- The entire process articulated in this paper represents a proactive approach to managing the quality of work environments. If the team or corporate culture resists such an approach, consider the

need for a more formal workplace change communication programme to increase the chances for success.

- Finally, treat the process of collecting feedback on the work environment, learning and change as a process of continuous improvement, not as a finger-pointing exercise for assigning blame for mistakes. The team should be aware that the workspace presents an opportunity for continual realignment of design features with the goals and aspirations of the organisation.

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9. Coleman, ref. 2 above.
10. Eckes, ref. 7 above.
11. To control for the impact of extraneous variables on the main effects, partial variance regressions were calculated on each of the KPIs, using data from the control group. Thus, the scores plotted in Figure 3 show the effects of the redesigned work environment using the control group data as a baseline.