BEHAVIOURAL-BASED SAFETY IN THE MINERALS INDUSTRY: A RESEARCH BASED METHODOLOGY CARRIED OUT IN THE UK QUARRYING SECTOR

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ABSTRACT

Behavioural-based safety (BBS) initiatives have proved to be successful across a wide variety of industries, through their unique bottom-up approach to health and safety management in the workplace. Whilst BBS has been identified as a possible tool to break through the accident plateau of the minerals industry, there is a lack of research into its effectiveness within this industry. Moreover, certain procedures deemed to be essential for the success of such an initiative appear incompatible with the industry's organisational characteristics and culture.

This paper will consider previous research on this subject and describe the Minerals Industry funded research that has been trialling the behavioural approach's applicability to the minerals industry through implementation of a BBS programme into two UK quarry sites. An outline of this process will describe the practical issues of applying the six-stage agenda to the quarries and reveal the project results that indicate a promising picture for behavioural safety for this sector. Early findings support an alternative form of behavioural measure that draws upon a combination of self-report and traditional methods of observing others onsite, which is more viable within this sector that comprises typically of a low number of employees but many lone workers.

INTRODUCTION

There are approximately 3000 quarries in the United Kingdom employing some 35,000 people. The industry produces an estimated 290 million tonnes a year, and mineral extraction and processing contribute approximately 8% of UK GDP. The products of the quarrying industry such as limestone, sandstone, sand & gravel, slate and china clay are essential to every-day living and critical to the maintenance of the economy and living standards, and this is expected to grow by 20% over the next decade due to the impact of more construction and road building projects.

However, quarrying is a dangerous industry. Towards the end of the 1990's the industry had injury rates which were significantly greater than a number of industries perceived as being 'high hazard' (such as construction). This led to the industry to sign up to the 'Hard Target' initiative to reduce accidents over a five year period from 2000-2005 (Foster & Pearce, 2003). At the end a reduction of 52% was noticed. Following this success the next stage of the initiative (2005-2010) will be to achieve a further 50% reduction in injuries by 2010 with the ultimate aim of zero incidents by 2015. As well as being a numerical target, the 'hard target' consists of a number of initiatives designed to improve the competence of its workforce, in particular their education and training with respect to health and safety. To ensure the continuing success of the Hard Target it is important to continue to address the underlying causation of injury at quarries. This has led to many calling for a re-focus on the human element of accidents in this industry (Peters et al, 1997; Geller et al, 2001; Galvin, 2005).

Indeed, examination of the main causes of injuries at quarries and mines supports the widely accepted fact that over 90 percent of workplace injuries are the result of workers' unsafe behaviours. The most common injuries across quarry and mining sites are manual handling, transport, falls from height, and slips & trips. All of which are attributable to unsafe acts of the employee.

A well-documented approach that focuses on such unsafe acts in the workplace is that of Behavioural-Based Safety (BBS).

What is Behavioural-Based Safety?

BBS is the application of psychological research on behaviour applied to safety in order to reduce accident and injury in the workplace. BBS has derived from behavioural learning principles conceived by behaviourists during the late 19^{th} century and developed into an approach through integrating organisational development with quality and safety management.

Elementary behavioural principles concern the events that affect the behaviour, including the cues that precede (Pavlov, 1927) and the consequences that follow (Skinner, 1969) the behaviour. Incentives, feedback and goal-setting all rise from this theory that behaviour is a reaction to its cues and consequences. For its application to safety in the workplace supplementary pertinent features constitute the typical current day BBS processes. Geller et al (2001) proposed four essential processes to employ in a behavioural-based system for mine safety: (1) Define target behaviours; (2) Observe critical behaviours; (3) Intervene for instruction, support, motivation or safety self-management; and (4) Test the impact of the process.

Success of BBS Across Industries

Success of BBS applications has been found across a great variety of industries. Evidence of this is provided by critical appraisals of the BBS approach and examination of studies evaluating BBS interventions that have involved a cross-section of industrial sectors.

McAfee and Winn (1989) reviewed 24 studies that investigated the effectiveness of behavioural approaches that used incentives and/or feedback in commercial organisations. They affirmed that all without exception showed improvement in safety performance through reduction of injury figures and/or an enhancement of safety-related conditions. Similarly, Guastello (1993) examined the effectiveness of 53 accident prevention programmes, noting, “behavior modification techniques are potentially useful in many industries”.

Whilst extremely positive, these evaluative examinations were restricted by time and have also been criticised for including too few studies. A more longitudinal study was carried out in 1999, which went beyond examining previous studies by investigating industrial approaches directly. Krause et al (1999) conducted a thorough examination of 73 BBS applications in the US over a five-year period, revealing highly significant success rates of the approach across sites. Safety performance based on the measure of improvement of injury rate was found to have an average increase of 26 percent after the first year of the approach being implemented and an average of 69% increase by the fifth year. This research involved a good cross-section of industrial sectors, including paper, petroleum, chemical, and food.

At first sight, this bodes well for extractive operations contemplating to take up this apparently versatile approach. However, the occupational settings of quarrying or mining have not been adequately represented in appraisals. This lack of representation is likely due to the limited number of researchers that have tried and tested the BBS programme in quarry or mine sites.

BBS Applied Research in the Minerals Industry

Fox, Hopkins and Anger (1987) initiated a token-based reward system to improve safety performance at two open-pit mines. Trading gift stamps were awarded to the full staff of mine employees primarily in return for not having accidents or injuries. The awarding initiative continued over 11 and 12 years. The considerable decline in lost time injuries (subsequent to the introduction of the incentive measures) provides support for the use of behavioural programmes in mining/quarrying operations and further demonstrates that the success of these programmes need not be short-lived. Also in the setting of coal mines, Rhoton (1980) succeeded in reducing miners’ safety violations with behavioural techniques including observation, reinforcement and feedback.

More recently, in a quarry setting, Hickman and Geller (2003) applied a specialised BBS strategy, the ‘Self-Safety Management’ approach (SSM), to improve quarry safety practices. Fifteen workers from a US stone quarry were divided into two separate conditions that involved different types of feedback on target safety behaviours. The SSM process involved identification of safe and at-risk behaviours, SSM training, daily self-monitoring, selfadministration of rewards, and individual feedback. Both conditions showed a positive increase in operative safety behaviours, and the overall SSM approach showed statistically significant improvement on the target safety behaviours.

Other researchers have examined and provided guidance on aspects of behavioural safety in mining operations (Talbot et al, 1996; Schutte, 1998; Laurence, 2005; Pitzer, 2005;). For example, research focusing on miners' compliance to safety procedures and regulations reveal such regulations alone will not reduce operatives' safety violations (Laurence, 2005) and that measurement of safety behaviour in mines is required in order to encourage compliance with these procedures (Talbot et al, 1996).

The Unique Work-Environment of the Quarry

Owing to this limited research and occasional company efforts (Simpson et al, 1993; Irca, 2003), sites may find themselves in the position of having insufficient information to guide them through an initiative. This drives the need to capitalize on literature pertaining to similar work settings. An important characteristic of the quarry and mining setting is the small workforce, many of whom work alone. Unfortunately, as well as a lack of evaluative research of BBS with lone workers (Olson and Austin, 2001), there are misleading reports on a fundamental component of BBS. Specifically, due to the majority of previous BBS research concentrating on work environments that are conducive to work colleagues systematically monitoring one another's safety-related actions (Hickman and Geller, 2003), often reports describe this use of peer-reporting as vital to the BBS system (Krause, 2002). Yet, as well as being incompatible to the physical layout of a quarry, the culture of the close-knit quarry is one where operatives are suspicious of providing information on their fellow workers' bad habits, perceiving it as "snitching" on their colleagues.

An alternative observation measure appropriate for this exceptional work environment is that of self-observations. Support for the use of self-observations include the success of the SSM approach that utilises safety self-monitoring, along with research that has found self-monitoring to improve safety performance as part of a BBS measure (Olson and Austin, 2001) and international behavioural safety experts that have endorsed self-reporting as a legitimate BBS measure with lone workers (Krause, 1997; McSween, 2003).

OVERVIEW OF CURRENT STUDY

The present study is a Camborne School of Mines led initiative, funded by the Minerals Industry Sustainable Technology Programme (MIST) and supported by the Health and Safety Executive (HSE). The minerals company, WBB Minerals Ltd, have offered their quarries to trial a behavioural safety process, which is based on both academic research and commercial recommendations. The (BSQ) process has been put into practice at two quarry sites.

1. Objectives

To highlight unsafe behaviours common to the quarry sector, identify root causes of such behaviours and to develop a behavioural-based safety process applicable to quarries.

2. Methodology

2.1 The Sample

2.1.1 Setting

WBB Minerals Ltd (WBB) is one of the world's largest suppliers of industrial minerals, producing a wide range of products from ceramics to construction material. The sample for this study is from two of WBB's quarrying sites based in the UK, each of which generate different products from separate geographical regions. The first site contains ball clay, china clay & kaolin quarrying and processing operations in the South West of England; the second site comprises of two silica sand operations in the North West of England.

2.1.2 Participants

The participants are the 179 staff employed on these sites. This includes 125 employees at site 1 and 54 at site 2. All 179 employees are considered to be involved in this study, unless they decide not to participate by choosing not to engage in key elements of the process, all of which are voluntary. Participation measurement was calculated throughout these elements.

At each site, a project steering team guides the BBS process. The teams are made up of five (site 1) and seven (site 2) front-line employees (operatives) from both quarrying and processing operations. These operatives represent a cross-section of core workers and contractors from each department. In one team, a manager is included in the steering team to provide access to senior management and able to offer immediate decisions at a local level.

Team members were selected at random by human resources personnel and approached for voluntary participation. Management approved these candidates as workers that would contribute well.

2.2 Procedure

The steering team directs the operatives through the 6 phases of programme (see below), which involve self and peer observations as the behavioural measure, and feedback, goal-setting and rewards as the instigators for behaviour change.[1]

Phases of the Behavioural Safety in Quarries (BSQ) Programme

Phase 1: Introduction of the Programme and Data Collection
Phase 2: Identification of Key Safety Behaviours (KSB)
Phase 3: Behavioural Observations (Self & Peer-Observation Checklists) & Training
Phase 4: Analysis of Root Causes
Phase 5: Making Changes, Reinforcement Schemes, Feedback & Goal Setting
Phase 6: Evaluation of Programme Effectiveness & Plan for Continual Development

Phase 1: Introduction to Programme & Data Collection

Initial data was collected through the use of focus groups, questionnaires[2] and interviews to obtain information on the current safety culture, systems and controls and to find out whether the company and the sites in question were ready for such an initiative. Injury and near miss records were also analysed in detail and fed back to middle management and senior boardroom executives.

Management, supervisors, operatives and contractors participated in three separate workshops detailing the underlying principles behind BBS and an outline of the BSQ process.

Phase 2: Identification of KSB

Formation of the Steering Team: Next, a steering team was formed at each site. Their role to shape and guide the process include the following primary duties: participating in safety steering team meetings on a weekly basis; promoting workforce ownership of the process, identifying and defining key safety behaviours; developing behavioural observation checklists; planning the observation strategy, conducting and assisting with observations; retrieving observation data and storing them in a safe place; providing feedback on progress and safety results; facilitating safety goal-setting; and proposing action plans based on the root cause of unsafe behaviours.

Certain researchers have argued against the use of the steering team, suggesting that the team “divorces the [BBS] process from the workforce” (Cooper, 2000). This may hold true for many organisations. However, due to a large number of lone employees and difficult shift patterns, it is challenging to assemble workgroups to act as their own steering committees. It is also impractical to hold regular meetings with the entire workforce and uneconomical to have regular meetings in each separate work area. Additionally, the communication systems within quarries are far removed from electronic correspondence akin to that used in office settings. Therefore, for such workplaces, the most appropriate method of stream-lining information back to the operatives is through a steering team that consists of members from each quarry division, with occasional meetings involving all workers. Each team member updates their departments’ workers on the weekly steering team meetings, ensuring full involvement of workers at the front line. This also facilitates the operatives’ ownership of the

[1] Currently, the process is at phase five, and has been rolling over a period of one year.
[2] The safety culture questionnaire produced a response rate of 78% (68% at site 1; 87% at site 2).

programme, as it is their colleagues rather than management or external consultants that are requesting/distributing information and feedback throughout the process.

Identification of the Top 20 Key Safety Behaviours (KSB): The team carried out individual interviews with workers on what they believed to be the most important and prevalent unsafe actions onsite. One hundred and twenty-seven operators[3] gave their views and ratings on what they perceived as either insignificant or central to site safety based on a list compiled from initial data collection (injury, near miss records and interviews) and steering team meeting discussions. This information was collated and the top 20 key safety behaviours (KSB) finalised.

This involvement from the workforce served to facilitate operative ownership of the programme and increase cooperation and acceptance of checklists incorporating the 20 KSB selected.

Pareto's law dictates that 80% of the consequences stem from 20% of the causes. Applied to accidents, this principle prescribes that, at any given time, 20% of behaviours are responsible for 80% of accidents. Therefore, logic dictates it is more productive to focus on a restricted number of critical and current behaviours rather than overload the workforce with all safety acts performed onsite. The present process involved a parameter of 20 behaviours. Working on the assumption that these 20 behaviours are the current 20 out of 100 behaviours (20%) that are actually responsible for 80% of the accidents, this figure was determined on the premise that this will limit dilution of focus and still be an adequate number of acts to focus on to achieve the desired results.

The KSB themselves had parameters attached to them: They had to be observable, specific and perceived as a major safety issue at the site and/or liable to cause an accident. The selected KSB were defined with precise specificity to reduce ambiguity of the safety act and increase reliability of their measurement.

Phase 3: Behavioural Measure

The purpose of this phase was to obtain a current baseline measurement of the twenty KSB and simultaneously gauge the operatives' preference of self or peer-observations on these twenty, as well as assessing the observational measures themselves through comparison of the safety results from these two different methods of assessment. The one-tailed hypothesis was that the majority of the workforce would favour the method of self-reporting. This was based on consideration of the nature of quarries as having a physical layout unsupportive of peer monitoring and on operative's loyalty to co-workers influencing them to prefer reporting their own prohibited actions rather than informing on the prohibited actions of others.

Training: All operatives were supplied with an observation training workshop, including demonstrations of how to conduct observations using checklists. Detailed definitions and workplace related examples of each KSB were provided.

No Blame Policy: Emphasis was placed on anonymity and confidentiality of the checklist responses. A 'No Blame Policy' attached to the behavioural measure was issued and a leadership commitment statement to the no blame policy and BBS initiative was signed by senior management and middle management from the relevant sites. This policy guaranteed that no one would be disciplined for anything written on the checklists.

The choice of Checklist: All operatives, including hauliers and other contractors, were offered the choice to complete either a 'self-report' checklist or a 'peer-observation' checklist (see Figure 1 & 2 for checklist preference and associated safety percentage). These checklists cover the same twenty key safety items with different phrasing. The self-report sheet allows operatives to record and comment on their own safety actions, whilst the peer-observation sheet enables logging and comments on the safety actions of others onsite.

[3] The KSB involvement form had a response rate of 82% (79% at site 1 and 88% at site 2).

The design of the Checklist: The checklists were of simple design, requiring the operatives to either tick 'yes', 'no' or 'non-applicable' for each safety item listed. Whilst marking responses with ticks served to reduce demand for written responses, which most operatives agreed that they would rather avoid, the operatives were still encouraged to write down their reasons for their unsafe acts on the back of the sheet. Those completing the peer-observation checklist on other workers' actions were advised to ask for the reason the unsafe act had occurred. For those with literacy difficulties, steering members and other workmates read and wrote on the observer's behalf.

The Collection of Checklists: at the end of the quarry workers' shifts, steering team members collected completed checklists. These checklists were either placed into election type boxes scattered around the site, or handed back directly to the members, often via work group team leaders.

Baseline Observation Period: To capture the baseline measure of KSB, operatives were instructed to conduct observations on a daily basis for a period of one month.[4]

Scoring & Feedback: To obtain a concise measure of the KSB from the checklist responses, the Behavioural Safety Index formula (Komaki et al, 1978) was used. This divides the number of safe observations by the total number of safe and at-risk observations, multiplied by 100[5].

Checklist responses were entered into spreadsheets that automatically calculated the safety percentage by applying the BSI formula to the data entered. A collective safety percentage was established on a weekly basis over the four-week observation baseline period (See Figure 3 for weekly BSI). These safety figures (combined to ensure anonymity of individual operatives) were fed back to all operatives via weekly toolbox talks. The manager in the steering team also provided feedback to the rest of the managers at their monthly manager operations review meetings.

Steering Team Observation Baseline: In addition to the operatives' baseline measurement, the steering team carried out their own month of peer-observations. This acted as a crosscheck on the operatives' checklist safety scores and was designed to enable future safety targets to be based on this objective base measure. (See Figure 4 for comparison of steering team and operative safety percentages).

Inter-Observer Reliability (IOR) Checks: Further accuracy checks on the reliability of the steering team's observations were carried out by dividing the number of times observers agreed by the total number of times observers agreed and disagreed, multiplied by 100. The steering team's IOR was at 100%.

Phase 4: Analysis of Root Causes

Analyses of the Key Safety Behaviours were used to arrive at the underlying reason for the at-risk behaviours.

As part of 'Functional Analysis', the A-B-C technique was used on the comments from the back of the checklists and from the information gathered in Phase 1. The A-B-C approach involves drawing out the **A**ntecedents (or cues) of the **B**ehaviour and its **C**onsequences.

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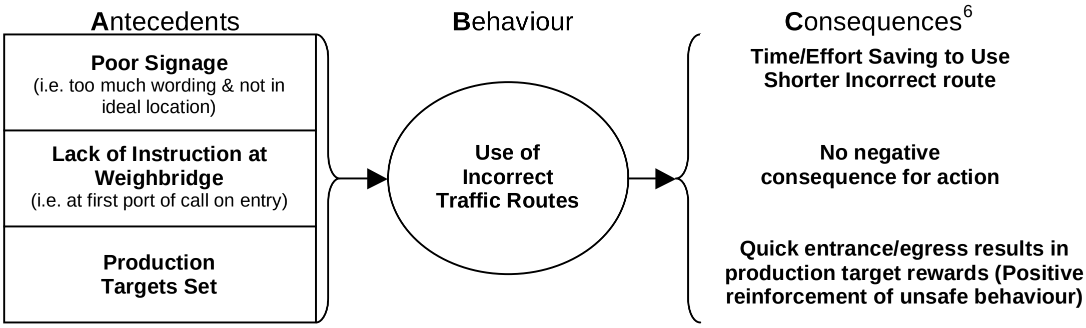
4 Actual participation was calculated as each worker completing one checklist every other day. This was determined by the number of workdays divided by the number of checklists per employee over 1 month.

5 The checklists used in the present programme involved only one count of each unsafe act per day (i.e. frequency of an unsafe act was not recorded). This was to simplify the observation process and, due to hazardous operations, operatives completed their checklist at the end of the shift, by which time it may be difficult to recall the accurate number of times the unsafe act had occurred.

Below is a study example of ABC analysis on the KSB of 'use of incorrect traffic routes'.



Operatives were also involved in the identification of the root causes, via each steering team member asking a selected few why they carry out at-risk KSB.

Phase 5: Making Changes

Action Plans & Changes: Based on the core root causes exposed, strategic plans were drawn up to act on the instigators of poor safety performance. Proposed strategies were assessed in terms of estimated impact on safety and on expenditure. The action plans were submitted to management via an operations meeting, along with evidence in the form of summarised operative responses.

The interventions and proposed changes comprised of adjustments on safety controls (e.g. training), amendments to certain antecedents (e.g. signs, safety-targets, relocation of safety equipment), re-design (e.g. seat belts) and consequences (e.g. rewards for safety).

Reward Schemes & Goal-Setting

Safety Bonus: At site 1, the launch of a collective safety bonus was designed to combine incentive and safety goals on the twenty KSB. This bonus replaced the previous company safety bonus scheme that relied on reported accident targets alone. The new system consists of an annual bonus to be paid out to operatives if they achieve a safety index percentage of 85%[7] on both operative observations and on observations conducted by the steering team.

Individual Safety Rewards: As rewards are most effective when they are more immediate following the act, individual safety rewards were introduced to accompany the collective safety bonus. This reward scheme dictates that if an operative is observed carrying out a safe act on the list of twenty KSB, they will be awarded with a safety raffle voucher. The voucher's stub is entered into the weekly raffle draw. At the end of the week, five winning vouchers are pulled out of the box and five prizes awarded.

Due to the spread of quarry workers around the large sites, distributors of these vouchers include a wide range of operatives to ensure a fair coverage of all work areas and help to involve more workers in the practice of rewarding their colleagues. Besides the steering team, distributors include site safety reps, NVQ assessors, team leaders and supervisors.

Phase 6: Evaluation of Programme Effectiveness

Evaluation: Towards the end of the BSQ initiative, the final phase is to evaluate the programme effectiveness in respect to safety performance and in terms of applicability of measures. The difference between baseline and intervention will be analysed. This includes a comparison of the accident rates, safety attitudes from the questionnaires, and a comparison of the safety percentage levels on a second behavioural measure that will be taken over a period of one month to determine the progress on the KSB.

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[6] Impact of consequences are further analysed according to their timing, certainty and significance.

[7] The figure of 85% was decided upon after considering the baseline BSI.

Final Feedback Session: At this final stage, it is crucial that the concluding results and implications of the study be fed back to the workforce and a strategy established to maintain improvements to safety for the future.

3. Results and Discussion

The following graphs are generated from the one-month daily observations baseline measure.

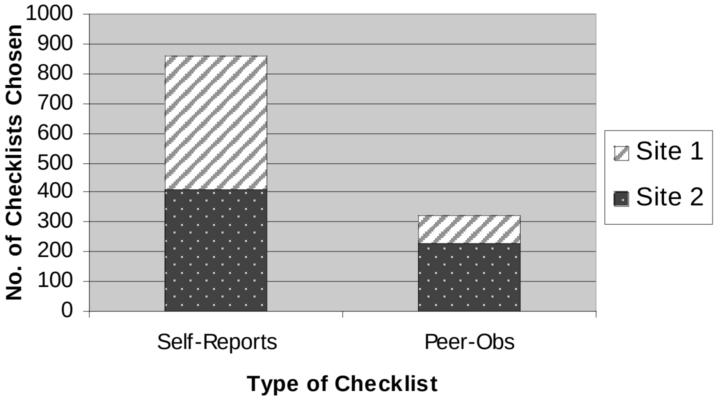

Figure 1: Type of Checklist Preferred

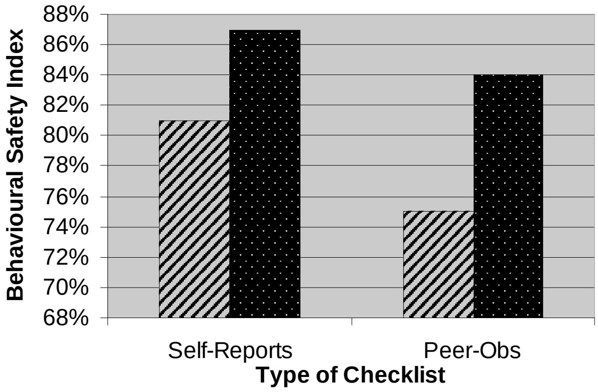

Figure 2: BSI by Checklist

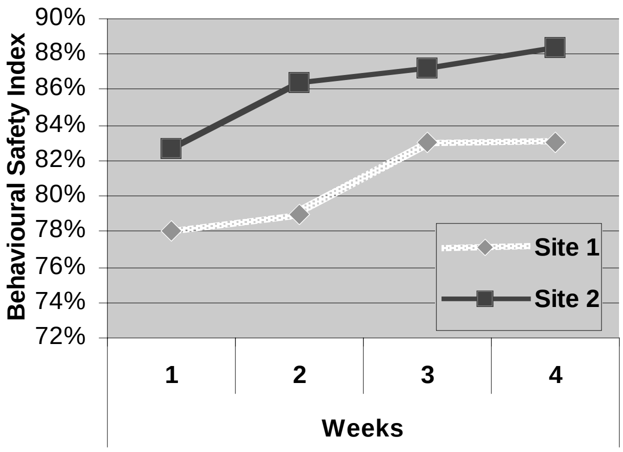

Figure 3: BSI of Combined Checklists

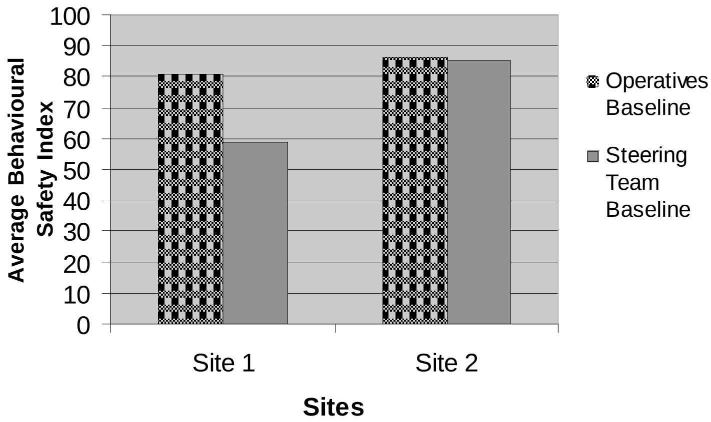

Figure 4: BSI of Two Monthly Baseline Measures[8]

Figure 1 demonstrates that self-observations have been particularly well received and favoured over peer-reports. This is true for site 1 significantly more than site 2, which may be on account of culture differences at each site, with site 1 owning a more close-knit workforce.

From Figure 2 it can be seen that self-reports have assessed a higher number of safe acts compared with peer-reports. This may be attributable to a lack of self-awareness of own at-risk behaviours or indicate dishonesty in self-reports, corresponding to theories of self-serving and social-desirability bias (the former is the tendency to present information that will result in social approval from others; the latter refers to the inclination to accept responsibility for successes but not failures). Nevertheless, Figure 2 does depict a good level of honesty in recording unsafe acts, with an average of 18% at-risk acts reported (well-fitted to Pareto's Law).

Illustrated in Figure 3, the baseline measure of 20 KSB reveals a noticeable positive increase in the safety level at both sites. Often seen as a confounding variable, the 'Hawthorne Effect' is a likely cause for this increase. This is the sheer presence of behavioural monitoring alone inducing the desirable behaviour being measured. Again, this can be linked to social

[8] Note that the steering team only produced 104 observations, whilst the workforce completed 1186.

desirability bias to perform and is consistent with Alvero and Austin's (2004) conclusion that a process of self-monitoring improved participants' safety performance.

Moreover, whilst the measure was intended as a baseline period, certain behavioural techniques were involved; weekly feedback, visual and verbal, were used to achieve buy-in of the programme. Benefits of the behavioural practices may further explain the improvement in performance. For example, the operatives heighten their awareness to what they have agreed on as the most common unsafe acts onsite, and by approaching others to ask for their reasons for acting unsafely communication on safety is increased and instigates displays of 'propensity to actively care' (i.e. the pro-social tendency to help towards a safer workplace).

This said, it is important to note that one-month of measurement is not a considerably long period of time to assess behaviour, and external factors may be responsible for the change.

Still, anecdotal evidence further accredits a rise in safety to the BSQ programme, with managers reporting that operatives "already appear more involved in site safety" attributable to a rise in discussions on KSB.

The final graph, Figure 4, reveals two very different results for each site. Site 1 shows a considerable difference between the average safety percentages of the operatives baseline to that of the steering teams, whilst site 2 have an approximately equal safety percentage. The reasons for the contrasting results are not yet clear.

Another telling outcome from the project is that the list of top 20 KSB at each site had the following 14 KSB in common: Use of three-point rule, speed, use of traffic routes, driving with vehicle butt raised, cleaning spillages, priority to loaded/larger vehicles, seat belt use, removal of trip hazards, PPE use, near miss reporting, running/rushing, load carried over distance, use of tools, and use of safety harness. Further investigation on these 14 would ascertain whether these are common across industry, which would provide a generic starting point for BBS interventions.

3.1 Conclusion

The present study has encouraging implications for self-auditing safety behaviours, demonstrated by worker buy-in of the self-report; the increase in BSI (led by a majority of self-reports); and a substantial number of at-risk behaviours reported in the self-report checklists. However, the results imply that operatives may not have been as accurate in their self-reporting as they were in their recordings of others. Considering Hickman and Geller's (2003) assertion that "self-monitoring alone lacks the accuracy and credibility of a more objective observational system", a combination of peer and self-reporting is proposed to be more appropriate for behavioural assessment in quarry settings. This incorporates a selection of employees (who regularly move around site) to document safety actions of others, alongside lone workers recording their own acts to guarantee a valid number of responses and to ensure involvement of as many workers as possible.

To date, the trial of the BSQ process has applied BBS to two quarry sites and produced a workable method with preliminary results that indicate feasibility of a BBS programme in the minerals industry. Subsequent to the interventions period, the questionnaire and checklists will be repeated, which should provide us with a clearer indication of the effectiveness of the process. It is anticipated that this follow up will show a significant improvement in BSI, reduction in accidents, and improved safety attitudes and culture.

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