

The importance of human factors in mining productivity

by A. C. Lawrence*, D. Com., B. Econ. (Member)

SYNOPSIS

The paper outlines some of the views on the relationship between work attitudes and performance, and examines evidence derived from relevant research done in the mining industry. It is suggested that higher productivity within any given system of mining can be attained if attention is paid to the four factors that represent the CORE of human work performance: Competence, Opportunity (or Organisation), Recognition (or Rewards), and Expectations (or Enrichment).

SAMEVATTING

Die referaat gee 'n uiteensetting van sommige sienswyses oor die verband tussen werknemershoudings en werk prestasie, en ondersoek bevindings van toepaslike navorsing wat deur die mynboubedryf onderneem is. Daar word aan die hand gedoen dat hoër produktiwiteit binne enige gegewe mynboustelsel bewerkstellig kan word as daar aandag geskenk word aan die vier faktore wat die kern van menslike werkprestasie vorm: bevoegdheid, geleentheid (of organisasie), erkenning (of belonings) en verwagtings (of verryking).

INTRODUCTION

It is not uncommon for unsatisfactory levels of work performance in a mine to be attributed, to a greater or lesser extent, to unfavourable attitudes among officials and employees in the mine. The poor attitudes may be claimed to exist at one or more levels in the organizational structure. At different times, the charge may be levelled at mine-workers, miners, shift bosses, mine overseers, and sometimes even at higher levels. If questioned on this issue, it is likely that the managers of the mines concerned would often equate 'attitudes' with 'job satisfaction', or similar concepts of the way in which workers are mentally disposed towards their jobs.

Such views are based on the fairly prevalent assumption that there is a direct causal link between the job satisfaction and other attitudes experienced by individual workers on the one hand, and their work performance or productivity on the other. Favourable attitudes are commonly thought to result in a high level of work performance. In fact, it is sad, but probably true, that management's interest in work attitudes stems almost solely from their belief that by improving attitudes they can improve work performance.

The factual evidence supporting this belief is extremely tenuous, however, so far as both the mining industry and industry in general are concerned. The evidence suggests

that there are no real grounds on which to expect an improvement in performance by improving in the attitudes of employees. This statement needs immediate clarification. It does *not* mean (a) that work attitudes are unimportant—they are important in their own right, from several points of view, but not because they are linked with productivity, *nor* (b) that there are no human factors that directly influence work performance — there are, but in mining at the present time they are not attitudinal factors.

The aim of this paper is to outline some of the views on the linkage between work attitudes and work performance, to examine some of the evidence derived from relevant research carried out in the mining industry, and to propose a simple model that should be held clearly in mind when attempts are made to improve productivity in mining by getting the most from employees.

WORK ATTITUDES AND WORK PERFORMANCE

Job attitudes and job satisfaction in particular, have constituted a central issue in the field of industrial psychology for more than twenty-five years. The emphasis on job satisfaction has been so great, in fact, that the lack of evidence of its direct association with work performance is normally overlooked. Simi-

larly, the dominance of interest in job satisfaction has tended to obscure other human factors that may be more important to work performance in certain circumstances.

The extensive volume of research has provided grounds for a variety of contrasting theories about the place of job satisfaction in relation to work performance. A review of the literature suggests that most of these views can be accommodated by one or other of the four simple 'models' described below.

Satisfaction—Performance Models

According to a common hypothesis, various factors determine a worker's job satisfaction, and work performance is directly related to this satisfaction. The factors are sometimes considered to be intrinsic to the work itself (such as job content, variety, opportunity, and so on), or extrinsic (such as working conditions, social benefits, remuneration, and so on). On the basis of the assumption that job satisfaction determines work performance, attempts have been made to identify those factors about which management should 'do something' to improve job satisfaction and hence work performance. This is the basis of the old, and now largely discredited, 'human relations' approach to personnel management, but it nevertheless still has strong support



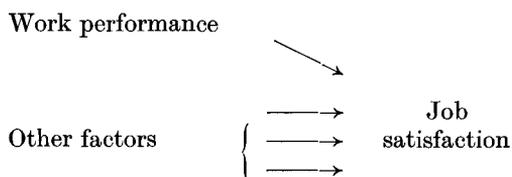
*Human Sciences Laboratory, Chamber of Mines of South Africa.

in some quarters. For example, Herzberg's 'motivation — hygiene' theory¹ is of this type.

It is interesting to note that, despite the implication that attention to Herzberg-type 'motivators' will improve work performance, there is little factual evidence in the research literature to support this view. Herzberg himself, in the initial formulation of the theory, was cautious about the connection between satisfaction/dissatisfaction and work performance, and seemed more concerned, and perhaps correctly so, about the need for attending to job satisfaction because of its importance for other reasons, such as the reduction in turnover and improvement in mental health.

The research findings can be confusing. There is evidence of association between high satisfaction and both high and low work performance, and similarly for low satisfaction. As early as 1955, Brayfield and Crockett², after an extensive review of the literature, arrived at two conclusions: 'first, that satisfaction with one's position . . . need not imply strong motivation to outstanding performance . . . and, second, that productivity may be only peripherally related to many of the goals to which the industrial worker is striving'. A later review by Vroom³ was equally pessimistic. He found that the median correlation between job satisfaction and work performance in a large number of studies was only +0.14. In other words, job satisfaction could explain less than 2 per cent of the variance in job performance.

Performance—Satisfaction Models



An alternative model, which attempts to explain the inconsistency in the connection between job satisfaction and work performance, simply reverses the direction of the link between them. Instead of claiming that an improvement in job satisfaction results in better work performance, it is contended that high work performance is one of the

factors, but not the only one, that results in job satisfaction.

This approach permits a neat explanation for the lack of close correlation between measures of job satisfaction and work performance by conveniently contributing low correlations to the presence of the other considerations.

Although useful if interest centres on 'job satisfaction', this model is not helpful in explaining how work performance can be improved, and little research interest has been shown in the model in its simple form. However, the performance—rewards model, which is described later, is a development of the idea.

Another way of explaining the poor association between job satisfaction and work performance is to postulate the presence of one or more intervening variables, and to attribute the lack of correlation to variations in an intervening variable. One such model has been proposed by Triandis⁴, and, although it has not attracted much attention and is not generally well known, it may have some relevance in mining.

Triandis suggests that the levels of both job satisfaction and work performance are determined by the 'pressure for high production' that

is exerted on workers, either by their superiors or by the circumstances in which the work is performed. In general, his view is that satisfaction is greatest when pressure for production is low, and that it decreases and eventually culminates in increasing dissatisfaction as pressure for production increases. Meanwhile, work performance varies non-linearly

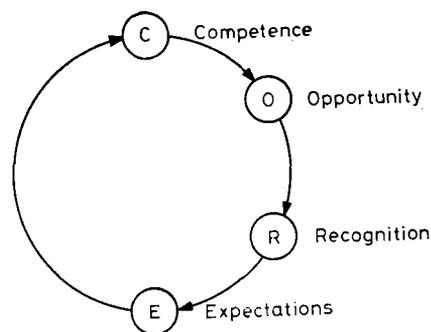


Fig. 1—The output—job satisfaction curve

with the increasing pressure.

Thus, as illustrated in Fig. 1, point A represents a condition of very low pressure for production with correspondingly high satisfaction. Production is low at this point, being just sufficient to relieve the worker of boredom and to satisfy his activity drives. If there is greater pressure for production, the situation moves through point B to point C. Here, work performance is very high and satisfaction is still high. Pressure increases beyond point C, however, reduce satisfaction to such an extent that production falls. At point D, the worker feels indifferent (neither satis-

Satisfaction/dissatisfaction

Pressure-for-production

Work performance

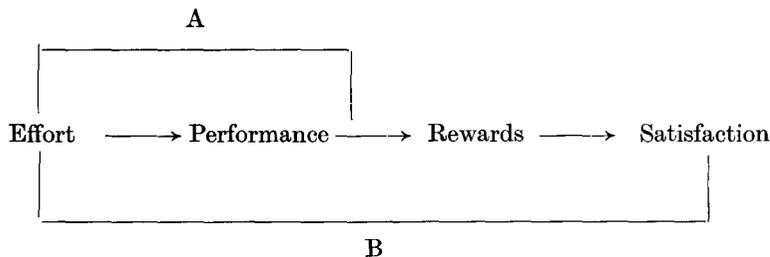
fied nor dissatisfied) and does just enough to permit him to 'get by'. If pressure increases still further (for example, if he feels the threat of being discharged), his production may rise to point E but it will be accompanied by increasing dissatisfaction. Under extreme pressure, say under extremely dangerous conditions where there is threat to life, work performance may rise even further, say to point F, but a slight increase in pressure may increase dissatisfaction to such an extent that the worker refuses to continue with the work and performance falls to zero at point G. Triandis has pointed out that, in practice, satisfaction/dissatisfaction outside the range XY is not normally encountered, but that within these limits it is possible

to find high production accompanied by both high and low satisfaction. Triandis 'takes the position that the ideal condition is one where the workers are most satisfied and output is highest *at the same time*' (that is, at point *C* in Fig. 1).

With pressure corresponding to point *C* in Fig. 1, work performance is high, workers are satisfied, and the situation has some long-term stability. A somewhat higher performance peak may occur at point *F*, where pressure for production is very high and workers are dissatisfied, but the situation is likely to endure for only a short period of time.

Although a search of the literature has not revealed any empirical support for this model, it seems to be worthy of further research. If correct, it implies that there are certain pressures that will ensure optimum production, and there is a need for more to be known about these pressures.

Performance—Rewards Cyclic Models



There is growing support for the view that an important variable intervening between work performance and job satisfaction is the one that describes the 'reward' the worker receives for his participation in the work. The term 'reward' is used in its widest sense, including not only financial incentives in the form of wages, bonuses, and so on, but also other more psychological rewards such as feelings of security, self-esteem, belonging, and participation.

This point of view has been ably presented by Lawler and Porter⁵⁻⁷. They have suggested that work performance depends on the exertion of effort and results in certain rewards for the worker. The amount of effort that the worker is prepared to exert depends on his estimation of the likelihood that he will receive

the reward, and on the value that he places on the reward if it is received. These feedbacks are denoted, respectively, by *A* and *B* in the above diagram.

This view suggests that 'rewards' are more important in securing high work performance than it has been fashionable for personnel management to admit in recent years, but only if there is a direct link between the value of the reward and the level of work performance attained, and only if the rewards for a given performance are perceived to be equitable. There is no suggestion whatsoever, in this view, that a general increase in reward (such as an overall rise in wages or an improvement in off-the-job benefits) will result in higher productivity.

The research findings⁸⁻¹⁰ tend to support the contention that satisfaction *follows* work performance appropriately rewarded (high performers rewarded, low performers not rewarded).

OTHER HUMAN FACTORS AND WORK PERFORMANCE

Consideration of the research evidence¹¹ leads inevitably to the conclusion that, if the focus of importance is work performance, then job satisfaction is *not* a determining factor but is more in the nature of a necessary by-product. It must be remembered, however, that research has shown a direct relationship between job satisfaction and job tenure (turnover)—or, in other words, that job satisfaction is important for reasons other than as a means for achieving a high level of work performance.

Although research has not systematically examined the role of human factors other than 'job satisfaction', some investigators have suggested the type of factors that may need to be taken into account. Two of

these observations appear to be particularly appropriate to the mining situation. They align closely with research findings in mining and with the suggestions in which this paper culminates.

If one reflects on the kinds of conditions necessary for productive work, it becomes quite clear that motivation is only one of them. Clearly, when working conditions, the quality of leadership, the suitability of supplies and equipment, the efficiency of scheduling and coordinating procedures, or the abilities of the members of the work force are found deficient, highly motivated behaviour may have either little effect on productivity or even possibly the effect of causing frustration which interferes with productivity¹² (p. 375).

There may be obstacles beyond the subordinate's control that interfere with his performance — such as lack of time, or conflicting demands on the subordinate's time, inadequate work facilities, restrictive policies or 'right ways of doing it' that inhibit performance, lack of authority, insufficient information about other activities that affect the job, and lack of cooperation from others with whom he must work . . . the operation of group goals and norms that run counter to organizational objectives,⁹ (p. 36).

A fair amount of evidence has already accumulated, and is continuing to accumulate, to support the view that, at present, a considerable variety of essentially 'human' factors, quite apart from job *attitudes* and job *satisfaction*, play an important role in limiting productivity in mining. These findings have been described in detail elsewhere, but the following brief summary is intended to bring them into the context of the present discussion.

(a) For more than twenty years, labour entering mining has been classified for different types of work on the basis of their intellectual abilities. The Classification Test Battery (C.T.B.) is currently used for this purpose. These tests have been validated¹³ against a training criterion; that is, the use of the test battery can be accepted as predicting with good precision the success that men will make of their subsequent *training*. Men who score high in the tests do well in training.

Unfortunately, because of the lack of suitable criteria for the assessment of an individual's contribution in most underground tasks, the relationship between test scores and *work performance* has not been well established. The assumption is usually made that training courses are effective, in that the men acquire

during training, all the skills necessary for the tasks they will perform. This assumption has, surprisingly, not been tested thoroughly, and this appears to be one of the major 'unknowns' relating to human factors in work productivity, particularly for supervisory jobs such as team leaders.

(b) In several surveys, mine-workers have been asked in various ways to identify the factors that they have found to be unfavourable in mining and that were a source of dissatisfaction. Although these surveys were not aimed at a study of work performance, one item that has emerged¹⁴ from among team leaders has been 'lack of materials'. The men have pointed out that, without the necessary materials, they could not achieve what was expected of them.

(c) A similar view has been expressed by shift bosses¹⁵. They have claimed that, unless they were given more direct control of the supply of materials to their sections, their forward planning could not be effective, and that lack of materials was the most important problem with which they were faced.

(d) From a study¹⁶ of locomotive-type accidents underground, it was concluded that, in general, they could not always be attributed to inadequacies on the part of the drivers, but were often closely related to organizational considerations. For example, it was suggested that pressure from supervisors for higher production resulted in malpractices that caused accidents, and hence interference with work performance.

(e) Men in mining continue to claim that their abilities are not being fully utilized. They say that the way mining is organized and managed does not provide sufficient opportunity for the individual to accomplish as much as he feels capable of doing. Young men in particular, be they learner officials¹⁷, shift bosses¹⁸, or graduate mining engineers¹⁹, are critical about the way in which their capabilities are utilized. The problem seems to be particularly serious among better-educated, ambitious young men.

(f) Personnel in mining are extremely mobile. The migrant nature

of the supply of mineworkers results in a turnover of about 100 per cent per annum. In addition, there is considerable movement of men within mines and, in the case of miners, officials, and managers, between mines. Much of this movement is beyond the control of the men concerned, but the serious impact that it has on productivity has been well demonstrated²⁰. For example, it was shown in one experiment that the productivity of stopping teams increased by as much as 20 per cent when the composition of the teams was kept constant. It has been suggested that optimum productivity cannot be attained without team effort, and that the considerable movement of men in mining interferes with the development of highly effective work teams.

(g) The quality of the supervision has also been shown to be important in determining the work performance of a production team^{21,22}. By 'quality of supervision' is implied the *competence* with which supervisors carry out their functions, and this matter is clearly but one aspect of the broader concept of competence. No worker can work with highest productivity if he is not competent, even if all the other relevant factors are favourable for high production.

(h) Consequent upon the multinational nature of the labour force in mining, there are major differences

between workers in language, culture, and possibly also work outlook and aspirations for the future. These differences may be sufficiently great to influence the work performance of work teams composed of men of different ethnic origins. Although there has been insufficient research to identify the relevant factors and to explain how they interact, at least one investigation²² has shown that the ethnic composition of work teams is not irrelevant as far as productivity is concerned. Work teams essentially of the same ethnic origin (Malawian in this case) produced at a level that was more than 10 per cent higher than teams in which there was not one predominant ethnic group.

HIGHER PRODUCTIVITY THROUGH ATTENTION TO HUMAN FACTORS

The considerable amount of research evidence reviewed above shows clearly that a significant improvement in productivity in mining is unlikely to be achieved if one or other of the many human factors involved is attended to separately and in *ad hoc* fashion. In particular, there is little likelihood that higher productivity will follow on measures that may improve job satisfaction.

What is needed is for management to review systematically the status

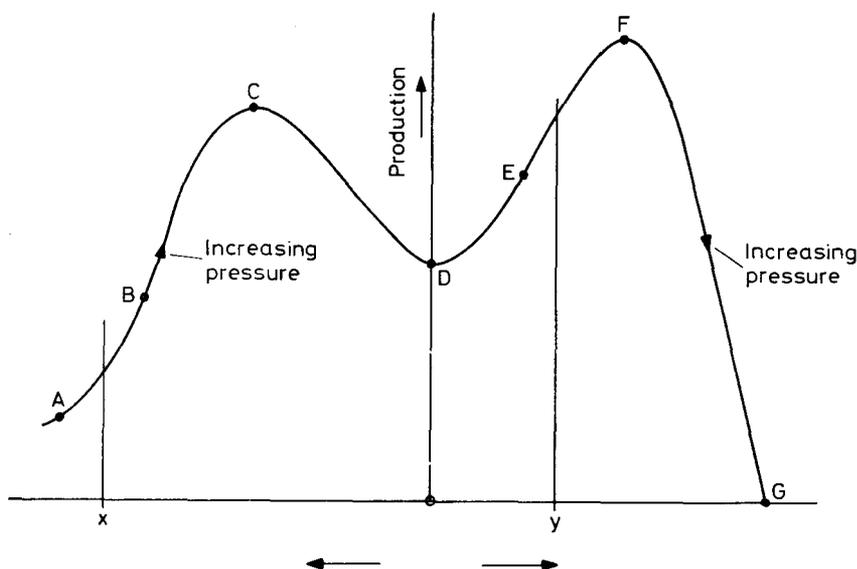


Fig. 2—The 'core' of work performance

of all the relevant factors on their mines, followed by suitable improvements so that the optimum relationship between them is attained. It is suggested that, for this purpose, the diverse matters referred to above may be sufficiently well-ordered for practical purposes if they are grouped into the simple cycle shown in Fig. 2. The acronym *CORE* is well suited to this model as the four components represent the core of the matter of human work performance.

Competence

The first consideration refers to the competence of the men. No matter how favourable other conditions may be, an incompetent employee cannot be a top performer. The concept of *competence* covers two main areas, namely (i) the selection of men for, and the placement of men in, jobs in which full use can be made of their abilities, and (ii) the proper training of the men to carry out these jobs.

Selection and placement procedures that are based on sound psychometric principles have been in use in the mining industry for many years. Training programmes for mineworkers have also been administered as routine for many years. Usually, courses are kept short, and the content is limited to what is considered the minimum necessary for the men to attain a satisfactory level of performance on the jobs that they will perform during their current contracts. In this way, training costs are kept to a minimum. There is an understandable reluctance for mines to invest in higher levels of training in view of the migrant nature of the labour supply and the lack of assurance that men will return to the mines on which they were trained.

As already mentioned, the problem of determining the validity or effectiveness of training programmes follows on the difficulty of establishing suitable criteria against which to judge the training. What seems to be needed is the development of reliable and valid 'competence' tests for key categories of jobs (such as team leaders) and the adjustment of training programmes to ensure that trainees attain a sufficiently high standard on these tests. Meanwhile, mine managements should review

their training programmes very critically. Are *job descriptions* sufficiently comprehensive and up-to-date? Are the *methods* used during training up-to-date and effective—to what extent has training lost its impact through years of routine administration? What is the level of the *passing-out tests*—how well do they reflect the ability of the men to do what is expected of them when they are placed on the job?

Opportunity (or Organization)

Given competent men, it is necessary to ensure that the circumstances in which they are placed are such as to permit them to function effectively. They must have the opportunity to accomplish what is expected of them, and this is largely a matter of job organization. This important area is largely a matter of management and responsibility, for it does not rest with the individual members of work teams. Team composition and complement, the extent to which teams are kept stable, the planning of the work, the specification of systematic and workable work methods, the availability of sufficient and proper materials, and the pressure for production are all relevant considerations in this area. Major improvements in productivity can be expected to result from more careful and detailed attention to these matters.

Recognition (or Rewards)

Through the years, difficulties have been experienced in providing effective pay incentive for mineworkers. These have included the establishment of suitable criteria against which to judge individual contributions fairly, the determination of equitable payment rates, and the devising of schemes that are simple to administer and that are easily understood by the men they affect. As a result, there are possibly more arguments against than for the use of pay incentives.

However, it must be remembered that, although pay is of major importance to the mineworker, it is not the only reward that he receives for participating in mining activities. Other rewards include personal recognition from supervisors for work well done, opportunity for promotion and for enriched jobs, association with high-

status highly productive teams, and so on.

The important point as far as productivity is concerned is that, whatever the form of the rewards given to the individual worker, they should be directly proportional to his personal contribution and must be seen to be so by the men concerned. If rewards are to contribute towards a drive for higher productivity, means must be found for satisfying these conditions. At the same time, it must be accepted that differential reward schemes may lead to an increase in dissatisfaction among the less-productive workers—on an undifferentiated basis their rewards would equal those of the high producers.

In view of the difficulties inherent in incentive pay schemes in mining, it is likely that the most effective reward scheme would be one that recognizes the high work performer by advancing him rapidly to more demanding, and higher-paying, jobs.

Expectations (or Enrichment)

The first three components, namely competence, opportunity, and rewards are matters that, if attended to, have the potential to result in an immediate improvement in productivity. However, there is a need, not for one single improvement in productivity, but for a continuing improvement over a long period of time. How then, having ensured that the men are competent, that they have the opportunity to work, and that their rewards are such as to encourage high performance, can yet higher levels of productivity be achieved? This is a longer-term problem and can be solved only by increasing still further the use being made of the abilities of the men in the labour force as time passes. Men who progress well through their high productivity can be expected to have even higher expectations for the future. These expectations can be met, to the advantage of both the worker and the mine, by ensuring that there is provision for men to progress to more rewarding work. This implies that there will be a need for them to learn new tasks and acquire new skills, which in turn requires the raising further of their competence and hence leads back into the first component of the

four-point cycle.

Higher productivity, within any given system of mining, can be attained if attention is paid to these matters.

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Contribution to the above paper

by H. G. M. Rose* (Fellow)

INTRODUCTION

Dr Lawrence is to be congratulated on his most interesting and instructive paper, particularly on his suggestion for a model to increase mining productivity through improved management performance. In view of an experiment initiated in one Union Corporation mine (Mine A) and later extended to a second mine (Mine B), it might be of interest to review the many human factors involved and the initial productivity results achieved. This experiment was based on the concepts and organizational changes laid down in a paper presented to the Association of Mine Managers of South Africa and entitled 'A Stopping Productivity Programme Instituted at Winkelhaak Mines Limited'.

Cyclic mining is not a new concept. Any successful mining operation must of necessity follow a logical sequence of events. Certain human

factors were, however, taken into consideration in the design of the cyclic mining operation in an effort to achieve greater productivity.

BACKGROUND TO THE EXPERIMENT

Towards the latter part of 1969, investigations were started on Winkelhaak with the object of establishing the reasons for poor performances in stoping contracts. Underground investigations by senior personnel revealed the following.

- (a) The stope work was being directed by the contractor, who, although highly skilled in the technicalities of stoping, had only a limited knowledge of how to organize the workers under his control.
- (b) In general, the shift-boss was no more experienced than the contractor in organizational matters and, as a result, did not interfere with the contractor's inefficient organization.

- (c) A slightly chaotic state of affairs existed in the stopes. An examination of stope sheets showed that some faces were being blasted only three times per month, resulting in an eight-day working cycle of operations. Investigations underground indicated that the cleaning operation was not in phase with the drilling operation. Machines continued to drill in a less and less efficient manner.

It appeared that senior management were at fault in that they had failed to clearly define and lay down what work was to be done and how it was to be done. It was decided to design a stoping operation in which a known amount of effective work would be performed daily. This work would have to be conducted in an orderly fashion by a trained labour force whose strength would be dictated by accepted work performance norms and the planned production objective.

*Consulting Engineer, Union Corporation.