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# Unsafe Behavior of Two Types of Miners Group

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## Abstract
With the shift of coal industry to intensive mining method, the miners with longer seniority but lower educational degree (experience miners (EMs)), and the miners with shorter seniority but higher educational degree (knowledge miners (KMs)), have gradually become typical miners group in the coal mine. However, how about behavior patterns and the occurrence mechanism of unsafe behavior (USB) of these two types of miners? It is still not clear. Therefore, the behavior patterns of the two types of miners are analyzed through the reference of literatures and theories. Then, a conceptual model of the relationship between two types of miners and USB, with self-efficacy used as regulating variable, with self-worth reinforcement (SWR) and external benefit reinforcement (EBR) used as mediating variable, was constructed basing on the social cognitive theory, and using structural equation model method validated it. Empirical study was conducted by means of questionnaire investigation and regression analysis. It shows that KMs are prefer to look forward to SWR and act safely under the action of SWR, EMs are prefer to look forward to EBR and perform USB under the action of EBR, moreover, EMs have a directly positive impact on USB. Self-efficacy (SFE) positively regulates the relationship between EBR and USB, and negatively regulates the relationship between SWR and USB.

## 1. Introduction

### 1.1. Background

The majority of coal mine accidents were caused by miners' USB in China [1, 2], drawing on the accident- causing theory and a great deal of accident investigations and analyses. One of the main reasons for that is the lack of work experience and culture quality. A series of publications have shown that the vigilance and sensibility of miners with junior education or below are less than those of miners with high middle school education or above [3], therefore, the coal mining enterprises whose miners have generally low level of education usually presented a phenomenon that there have been a high accident rate [4]. In addition, a number of studies have shown that the correlation degree between miners who own shorter seniority as well as lower educational degree and accident occurrence is higher, among which the miners with primary and junior education are most closely related to the accident occurrence [5]. As a result, the miners who lack work experience and culture quality are more likely to exhibit USB, conversely, it will be difficult.

Then, how about USB of the miners with longer seniority but lower educational degree, and the miners with shorter seniority but higher educational? With the shift of coal industry to intensive mining method, these two types of miners have gradually become typical miners group in the coal mines (Table 1). However, The behavior patterns of these two groups of miners as well as the correlation degree with accident occurrence are still not clear. Therefore, the occurrence mechanism of two types of miners' USB should be studied to provide strategies to intervene to prevent coal mining accidents.

### 1.2. Research Objectives

Statistics have indicated that the front-line workers with junior education or below account for 15.1%, high education account for 69.3%, college degree account for 15.6%, among five state-owned key coal mines in China [6]; 64.7% own more than 5 years of work experience, and 90% own high education or below, among five state-owned key coal mines in China [7]; 36% own junior education or below, 54% own high education, 10% own bachelor degree or above, and most of them have 6-10 years of work experience, among two state-owned key coal mines in China [8]. From the above, it could be seen that the majority of coal mining enterprises have still existed a phenomenon that front-line workers generally own a longer length of service but a lower degree of education, in the past 5 years. However, with the development of coal industry, the front-line workers' degree of education is also improving, especially the emergence of coal pillar robbing groups of undergraduates in a number of state-owned key coal mines make the proportion of front-line workers with higher educational degree increased.

The front-line workers who own 5 years seniority or less as well as own college degree or above were divided into KMs according to the above analysis as well as partition criteria for miners' seniority and degree of education in coal mining enterprises. Similar as the above, the front-line workers with more than 5 years seniority and with high education or below were divided into EMs. Therefore, KMs refer to the miners with shorter seniority but higher degree of education, EMs refer to the miners with longer seniority but lower degree of education.

## 2. Two Types of Miners' Behavior Patterns

### 2.1. Rationale of Human Behavior Patterns

There has been a long debate about whether human behavior depends on external forces [9] or internal forces [10]. The social cognitive theory [11] has organically integrated the above two perspectives and has a great impact on cognizing human behavior patterns. The core of this theory is the reciprocal determinism model (Figure 1), which demonstrates the dynamic reciprocal relationship between social environment, individual cognition and behavior.

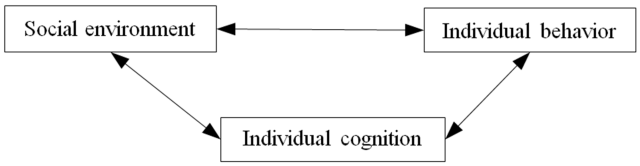



***Figure 1.*** *Reciprocal determinism model based on the social cognitive theory.*

At the same time, the model has distinguished human behavior from cognitive factors, and argued that individual cognition plays two roles in the process of determining behavior. One of the roles is individual cognition of behavior outcome, that means it is possible to perform the behavior when an individual learns by judgment that the behavior will achieve satisfactory outcomes. The other is individual cognition of self-ability (self-efficacy), that means it is possible to perform the behavior when an individual learns by judgment that they have enough ability to carry out the behavior bringing about satisfactory outcomes [12]. But satisfactory outcomes themselves cannot be reinforcing factors that ultimately motivate individuals to perform certain behaviours. Only when individuals own strong expectations for outcomes can they be reinforced. Then it has been found that self-efficacy has a regulating effect on the relationship between strong expectations on behavior outcomes and behavior. The regulation model is shown in Figure 2.

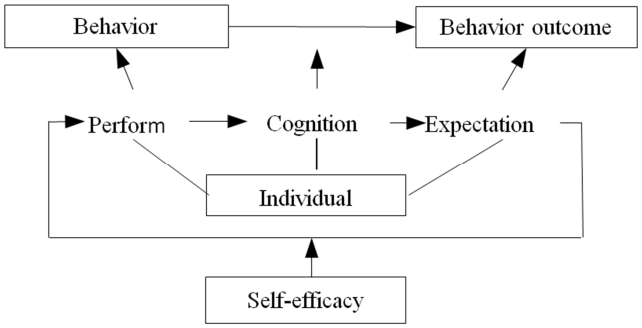



***Figure 2.*** *Self-efficacy regulation model based on the social cognitive theory.*

### 2.2. Theoretical Analysis of the Occurrence Mechanism of Two Types of Miners' Unsafe Behavior

Reinforcements expected by individual were divided into EBR and SWR in the present study. The EBR refers to the reinforcing effect of the external benefits brought by human behavior [13]. A number of studies have shown that the negative consequences caused by violations do not timely appear due to the low probability of the occurrence of accidents and injuries, but it could make workers feel an advantageous side in time [14], and then simulate workers to perform illegal operations to gain benefits about time-saving or labor-saving. If it goes on like this, workers will underestimate the occurrence of these probability events in the long-term work, and then gradually develop the habitual violation behavior [15]. The SWR refers to the process by

which an individual evaluates his behavior basing on a certain standard to reinforce and maintain himself to achieve standard behavior [16]. The majority of individuals who expect to achieve self-worth do not only accomplish tasks, but regularly pursue better ones. Therefore, two types of miners expect to get what kinds of reinforcements, which is decisive for the choice of behaviors. However, the two groups of miners may not be likely to carry out an act even though they have strong expectations for the reinforcements. Only when there is a higher self-efficacy will it be more likely to perform a safety or unsafe behavior.

EMs are able to create some values, but most of them are constrained by previous experience and seek only to accomplish tasks in order to gain EBR [17], as for completing the task in what way or how about the effects of tasks, it would usually not be considered [18].

The majority of KMs own corresponding professional specialties, higher personal qualities and a strong desire to realize their self-worth [19]. Although they don't have enough work experience, they have strong learning ability [20], and they accumulate experience in constant reflection and summary so as to achieve SWR [21]. The following hypotheses were proposed. Conceptual models are shown in Figures 3 and 4.

Hypothesis 1. EMs will be positively associated with USB, and KMs will be negatively associated with USB.

Hypothesis 2. SWR and EBR are hypothesized to mediate the relationship between two types of miners group and USB.

Hypothesis 3. SFE is hypothesized to regulate the relationship between SWR, EBR and USB.

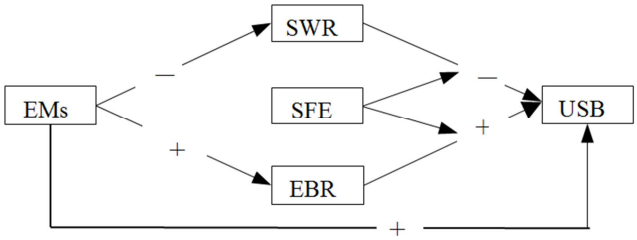



***Figure 3.*** *Conceptual model of relationship between EMs and USB.*

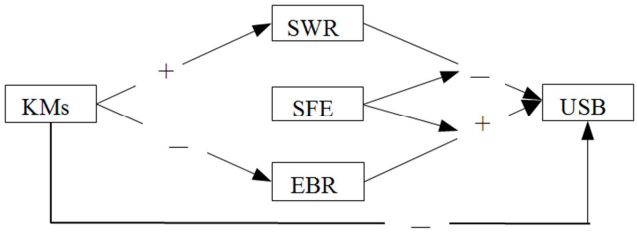



***Figure 4.*** *Conceptual model of relationship between KMs and USB.*

# 3. Methods

## 3.1. Questionnaire Investigation

Firstly, the variables involved in the questionnaire were defined and measured. KMs and EMs were measured by 3 self-reported items respectively on the basis of the characteristics of two types of miners; SWR and EBR were measured by 5 items totally on the basis of the "Internal-External Scale" developed by Rotter [22] and the concept of them; USB was measured by 10 items on the basis of the "Miners' Unsafe Behavior Scale" developed by Qu [23] and the common violations behavior in coal mines; SFE was measured by 6 items by integrating the items with similar meaning in the "Generalized Self-Efficacy Scale" developed by Schwarzer [24]. The Complete questionnaire is shown in Appendix.

Secondly, taking two large state-owned coal mines and a small local coal mine in Shaanxi as the sampling target areas, quota sampling was conducted on the basis of the total number of front-line miners. Questionnaires were sent to the front-line workers at regular security meeting. Succinctly answer questions that miners may encounter when filling out questionnaires.

Finally, because the questionnaire is not mature enough, it is necessary to analyze the reliability and validity of the questionnaire. The correlation and reliability of latent variables were analyzed by SPSS19.0, and the validities of convergent and discriminant of latent variables were tested by the confirmatory factor analysis.

## 3.2. Model Testing

The structural equation model (SEM) of the relationship between two types of miners and USB was constructed basing on the conceptual models and the results of reliability and validity analysis on the above. Using the maximum likelihood method from AMOS17.0 tested the fit of the model.

Regression analysis was used to examine the regulating effects of self-efficacy. Firstly, the independent variable, SWR or EBR was put into the regression equation, acquiring the model 1: $USB=a_0+a_1SWR(EBR)+\varepsilon$; Secondly, the regulating variable, SFE was put into the regression equation, acquiring the model 2: $USB=a_0+a_1\ SFE+\varepsilon$; Finally, the interaction term, the product of the independent variable with the regulating variable, was put into the regression equation, acquiring the model 3: $USB= a_0+a_1SWR(EBR)\times SFE+\varepsilon$.

# 4. Results

## 4.1. Sampling Results

As shown in Table 1, a total of 315 questionnaires were issued to the miners and 308 were recovered, with an effective rate of 88.9%. Among which, there have been 250 two types of miners, 15 other types of miners. KMs, EMs and OMs accounted for 21.1%, 73.2% and 5.7% respectively. In addition to the two types of miners, the number of OMs accounted for a very small part.

***Table 1.*** *The sampling situation.*

| Sampling target areas | Questionnaires | | | Numbers and proportions (%) | | |
|---|---|---|---|---|---|---|
| | Distribution | Recovery | Availability | KMs | EMs | OMs |
| LCM1 | 125 | 125 | 114 | 25 (22.0) | 81 (71.0) | 8 (7.00) |
| LCM2 | 115 | 112 | 102 | 27 (26.5) | 70 (68.6) | 5 (4.9) |
| SCM1 | 75 | 71 | 49 | 4 (8.2) | 43 (87.8) | 2 (4.0) |

LCM1 and LCM2 refer to two large state-owned coal mines; SCM1 refers to small local coal mine; OMs refer to other types of miners.

## 4.2. Results of Reliability and Validity Testing

As shown in Table 2, the values of Cronbach's Alpha of latent variables were all greater than 0.6. It indicates that the degree of internal consistency of observation variables was higher, and reliabilities of the scales were satisfactory, in terms of the reliability judgment standard [25]. The factor loadings of USB in Figure 5 were all greater than 0.71. It indicates that the homogeneity of the factor measured by USB1-USB10 was very high, that is, the scale of USB had a good convergent validity, in terms of the validity judgment standard. Similarly, scales of KMs, EMs and EBR also had good convergent validities. The factor loadings of observation variables of SWR didn't reach the criterion of 0.71, but the average variance extracted (AVE) of SWR was $0.679 > 0.5$. It satisfies another criterion of convergent validity [26], therefore, the scale of SWR also had good convergent validity. The correlation coefficients between latent variables were less than the square root of AVE. It indicates that there were obvious differences among latent variables, that is, they had good discriminant validity, in terms of the validity judgment standard [27, 28].

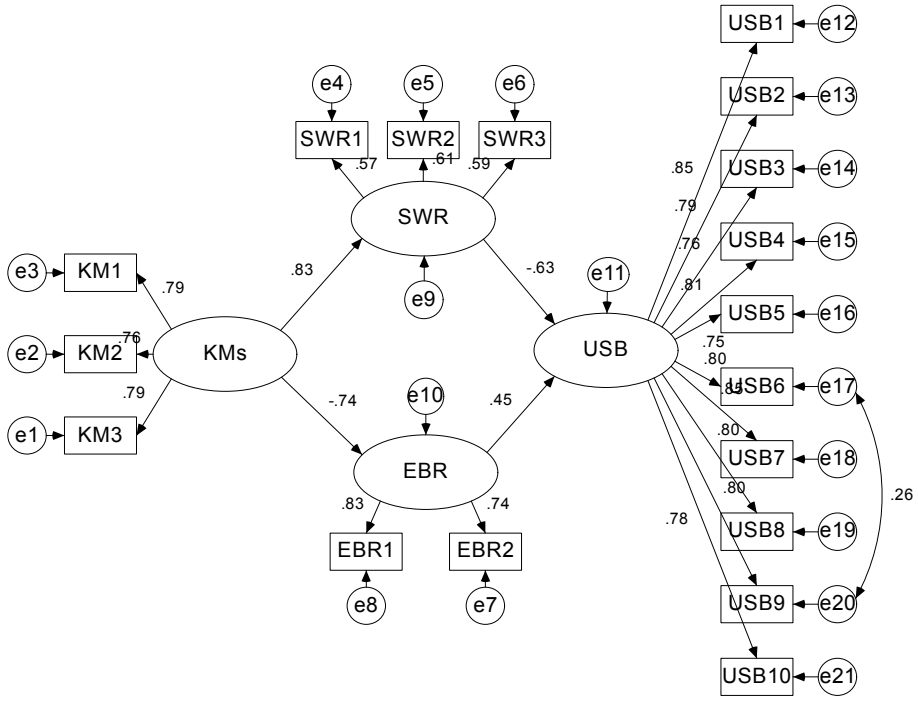
***Table 2.*** *Values of reliabilities, correlation coefficients, AVE and AVE square roots.*

| Latent variables | KMs | EMs | SWR | EBR | USB | Cronbach α | AVE |
|---|---|---|---|---|---|---|---|
| KMs | 0.914 | | | | | 0.830 | 0.821 |
| EMs | -0.736 | 0.938 | | | | 0.880 | 0.857 |
| SWR | 0.533 | -0.506 | 0.804 | | | 0.647 | 0.679 |
| EBR | -0.542 | 0.597 | -0.544 | 0.875 | | 0.766 | 0.740 |
| USB | -0.737 | 0.785 | -0.704 | 0.730 | 0.973 | 0.947 | 0.941 |

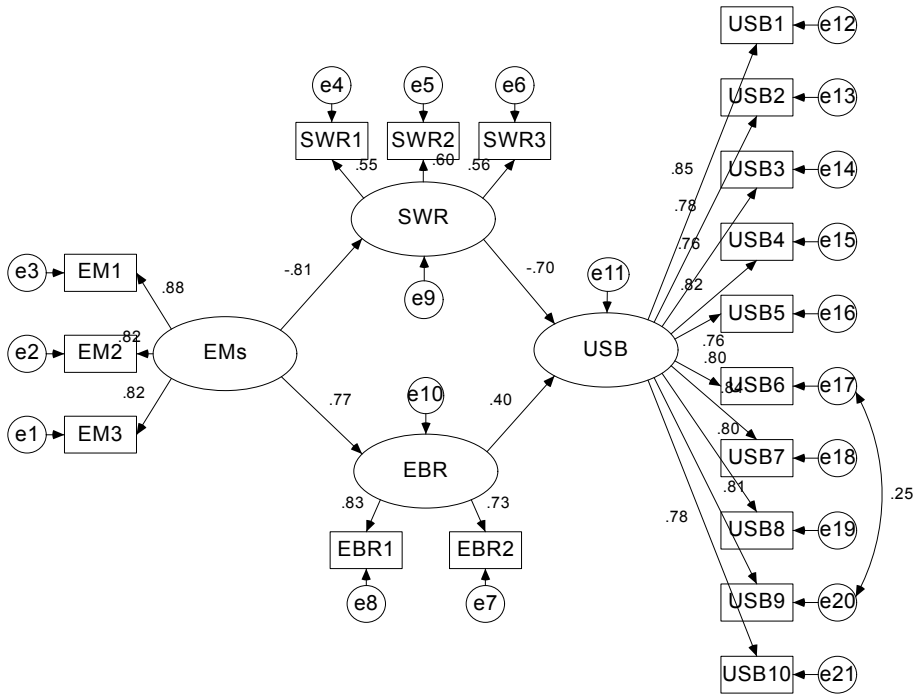
The diagonal is AVE square roots.

## 4.3. Results of SEM Testing

It was found that the path coefficient between KMs and USB didn't reach the 0.05 significance level by SEM testing, and other path coefficients were all statistically significant. The model was tested again after deleting the path that was not significant. The final model (Figure 5) was obtained after several modifications according to modification indices. As shown in Table 3, only two indicators, GFI and AGFI didn't meet the value of preliminary fit criterion, but they were close to it, which means that the SEM model fitted the data well.




Model 1




Model 2

***Figure 5.*** *The modified SEM model.*

***Table 3.*** *Fitting index values of model.*

| Statistical test values | | $\chi^2$/df | NFI | CFI | GFI | AGFI | IFI | RMSEA |
|---|---|---|---|---|---|---|---|---|
| Fitting criterion values | | <2 | >0.9 | >0.9 | >0.9 | >0.9 | >0.9 | <0.08 |
| Model 1 | modified | 1.671 | 0.918 | 0.965 | 0.901 | 0.871 | 0.965 | 0.056 |
| | unmodified | 1.591 | 0.923 | 0.969 | 0.907 | 0.877 | 0.970 | 0.053 |
| Model 2 | modified | 1.966 | 0.910 | 0.953 | 0.888 | 0.853 | 0.954 | 0.068 |
| | unmodified | 1.847 | 0.917 | 0.960 | 0.896 | 0.860 | 0.960 | 0.063 |

$\chi^2$/df: the ratio of the chi square to the degree of freedom; NFI: normed fit index; CFI: comparative fit index; GFI: goodness of fit index; AGFI: adjusted goodness of fit index; IFI: incremental fit index; RMSEA: root mean square error of approximation.

### 4.4. Results of Regulating Effect Testing

As shown in Table 4, both main effects and inter- action effects were significant at the 0.001 level, and all values of $R^2$ were greater than 0.138. It indicates that independent variables were highly correlated with dependent variables in all models, in terms of the judgment standard [29].

***Table 4.*** *The results of regression analysis.*

| Model | Regulation of the relationship between EBR and SFE | | | Regulation of the relationship between SWR and SFE | | |
|---|---|---|---|---|---|---|
| | Intercepts ($a_0$) | Coefficients ($a_1$) | $R^2$ | Intercepts ($a_0$) | Coefficients ($a_1$) | $R^2$ |
| Model 1 | 1.044*** | 0.661*** | 0.533 | 5.403*** | -0.866*** | 0.496 |
| Model 2 | 1.188*** | -0.534** | 0.440 | 1.188*** | -0.534** | 0.440 |
| Model 3 | 1.190*** | 0.203*** | 0.527 | 4.526*** | -0.195*** | 0.282 |

**Correlation is significant at alpha equals 0.01;***Correlation is significant at alpha equals 0.001.

## 5. Discussion

### 5.1. The Knowledge Miners' Unsafe Behavior

The path coefficients between KMs and SWR, EBR were 0.83, -0.74 respectively, those between SWR, EBR and USB were -0.63, 0.45 respectively, and all values of P were 0.000, it indicates that all coefficients were statistic- ally significant at the 0.001 level; The path coefficient between KMs and USB did not reach 0.05 significance level because the relationship between them was completely mediated by SWR and EBR. It indicates that KMs could only exert indirect influence on the USB through the transmission of SWR and EBR. Therefore, what kinds of reinforcements expected by KMs will determine whether or not they perform USB.

By analyzing indirect effect, was it found that KMs' USB was respectively reduced by 0.63, 0.45 units for each increased unit of SWR or EBR, when other conditions remain

unchanged. By analyzing regulating effect, was it found that the coefficient ($a_1$) between the interaction term that the product of SFE with SWR and USB was -0.195 at the 0.001 level, and the interaction term could interpret 28.2% of variance of USB. It indicates that the self-efficacy had a negative regulating effect between SWR and USB, that is, the higher self-efficacy KMs own, the more likely they are to perform safety behavior under the influence of SWR.

### 5.2. The Experience Miners' Unsafe Behavior

The path coefficients between EMs and SWR, EBR, USB were -0.71, 0.75, 0.29 respectively, those between SWR, EBR and USB were -0.48, 0.34 respectively, and all values of P were less than 0.01, it indicates that all coefficients were statistically significant at the 0.01 level. By decomposing the effects, was it found that the total effect of EMs on USB was 0.879, 32.5% of which came from the direct effect and 67.5% from indirect effects, namely, the relationship between EMs and USB was not completely mediated by SWR and EBR. It may result from unintentional USB caused by excessive confidence or habitual violation. The total effect of EMs on USB was higher than that of KMs's (-0.853). It indicates that the group of miners with rich experience but lack of relevant knowledge had a great influence on USB.

By analyzing regulating effect, was it found that the coefficient ($a_1$) between the interaction term that the product of SFE with EBR and USB was 0.203 at the 0.001 level, and the interaction term could interpret 52.7% of variance of USB. It indicates that the SFE had a positive regulating effect between EBR and USB, that is, the higher self-efficacy EMs own, the more likely they are to perform USB under the influence of EBR.

## 6. Conclusions

Based on Bandura's social cognitive theory, conceptual models of the relationship between the two types of miners and USB were constructed. Using SEM to verify, and using the questionnaire and regression equation to carry out empirical analysis, the following conclusions were drawn.

A group of miners with less work experience but higher degree of education (KMs) is more inclined to realize self-worth, and more often chooses to perform safety behavior under the action of SWR, so then, the correlation degree between KMs and accident occurrence is at a low level. It is lower in the case of owning a higher self-efficacy.

A group of miners with a longer length service but lower degree of education (EMs) is more inclined to get benefits arising from illegal operations, and more often chooses to perform USB under the action of EBR. At the same time, it is easy for the EMs to make USB directly without the action of EBR, so then, the correlation degree between EMs and accident occurrence is at a high level. It is higher in the case of owning a higher self-efficacy.

Two proposals were put forward through the above analysis. On the one hand, coal mining enterprises should increase efforts to improve working conditions and welfare, and attract workers owning higher degree of education to work in the front line; On the other hand, coal mining enterprises should promote EMs' knowledge level and broaden EMs' knowledge scope.

## Appendix Questionnaire

You will firstly select your level of education and seniority in the two option. Then, you will be presented with a series of statements about your psychology and behavior, and you should indicate a response by selecting one out of five agreements (1=strongly disagree; 2= disagree; 3=neither agree nor disagree; 4=agree; 5=strongly agree) in the box.

*What is your education level?*

a. high education or below ☐

b. college degree or above ☐

*How long is your seniority?*

c. 5 years seniority or less ☐

d. 4 more than 5 years ☐

*Knowledge miners* (*KMs/only the miners who satisfy items "b" and "c" fill out the following three items*)

1. I will apply what I have learned to my work ☐
2. I will try my best to use my professional knowledge to solve the problems encountered during work ☐
3. I will try my best to make my behavior conform to the standard ☐

*Experience miners (EMs/only the miners who satisfy items "a" and "d" fill out the following three items)*

4. Rich work experience makes my job easier ☐
5. I will use my work experience to solve the problems encountered during work ☐
6. I think work experience is more practical than professional knowledge ☐

*Self-worth reinforcement (SWR)*

7. Realizing self-worth at work is my motive force to go to work ☐
8. In order to complete the task better, I will try my best to work in a standard way ☐
9. The challenge of the job itself will stimulate my interest more ☐

*External benefit reinforcement (EBR)*

10. I will select a time-saving or labor-saving way to complete the task ☐
11. In order to achieve performance rewards, no matter what way, I will finish the task as soon as possible ☐

*Unsafe behavior (USB)*

12. I won't report it when I find a accident potential ☐
13. I will go to blind alley or somewhere else to rest during work ☐
14. I will take a risk enter hazardous sites ☐
15. I will not operate in accordance with standard procedures ☐
16. I will not travel by the rules ☐
17. I will not wear labor protection articles according to the regulations ☐
18. I will start working without checking the pillars and the roof ☐
19. I will use unsafe tools or equipments ☐
20. I will still work when notified of danger ☐
21. I will not attend the pre-shift and post-shift meeting ☐

*Self-efficacy (SFE)*

22. I can always manage to solve difficult problem if I try hard enough ☐
23. Even if someone opposes me, I can find ways to get what I want ☐
24. It is easy for me to stick to my aims and complete my goals ☐
25. I'm confident that I could deal efficiently with unexpected events ☐
26. I can remain calm when facing difficulties because I can rely on my coping abilities ☐
27. No matter what comes my way, I'm usually able to handle it ☐

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