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DEVELOPMENT OF THE CONCEPT OF OVERALL WORK COMPATIBILITY: INTEGRATING IMPORTANT WORK VARIABLES

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ABSTRACT

A work environment consists of a complex array of work factors that jointly influence work outcomes. Based on previous human performance models and theories, researchers have introduced the guideline principles of "Work Compatibility Theory", which is a comprehensive quantitative approach to solving the problem of human performance outcome. In the previous theories, work compatibility has been represented by a Work Compatibility Matrix (WCM) for each of the Work Compatibility variables. In this research, we tried to find out the Overall Work Compatibility (OWC) of a work environment (floor/shop/ organization) for each worker, taking into account all the WC variables and their mixed effects on human. Since the idea behind the WCM model is based on the positive and negative (or both) effects of a web of elements which might or might not be interrelated, an Artificial Neural Network (ANN) model was created to produce a comprehensive and holistic result.

Keywords: Work Compatibility, Overall Work Compatibility, Artificial Neural Network.

1. INTRODUCTION

Ever since the advent of scientific management theories, it has been clear to researchers that human's capacity to work or work productivity can be influenced unpredictably by multifaceted variables. It is not necessary that all humans are positively influenced by the same work variable, say management's concern. Managements' concern for an employee can have positive influence on some, but there are some employees who may think of it critically and reduce their productivity. Similar is the case with other work related variables. In fact, it is not solely positive or negative influence; a work variable can have somewhat positive and somewhat negative influence on a single employee. In attempt to measure this integrated influence, came the concept of Work Compatibility (WC) [1]. In previous research by Genaidy et al, a mathematical concept of work compatibility has been developed, where the WC of each work related variable is expressed in form of a matrix named Work Compatibility Matrix [2].

The WC Matrix represents the WC of a single variable. As we all would agree, a work environment is a complex situation where many work related variables are intertwined. The integrated effect of all the variables finally determines the work productivity of an individual. We seek to find this integrated effect of all the WC variables in a particular work situation. This is what we call the "Overall Work Compatibility" (OWC) of an organization. It has been taken in previous literatures that work productivity is directly proportional to WC [2]. Therefore, we represent the Overall Work Compatibility in terms of productivity of each employee, rather than a complex matrix. Also, with the concept of Overall Work Compatibility, we attempt to find the inter relation between the work related variables in terms of relative weights.

In computation of such a critical web of variables, the Artificial Neural Network (ANN) approach has been chosen. ANN has been used for a long time for prediction of values that emanate from variables that have seemingly capricious relationships. An ANN can be trained using past data and with the artificial intelligence thus developed, it can predict future data.

Past data from a local garments industry has been used to train the ANN, and thus the relative weights existing in the present variables were established. Using this information, the ANN can be used to predict future OWC of a situation.

2. LITERATURE REVIEW

As the practical life is approached, many of the challenges in the field of Human Factors are found in the complex interaction among man, machine, environment and the socio-technical systems [3]. The researchers are now approaching towards studying the interactions themselves rather than the factors or interfaces in a person's environment [4].

Today, the work environment presents unique challenges to different professionals because it consists

of a complex web of work factors that jointly influence work outcomes. The goal of system design with respect to work compatibility is to simultaneously maximize work productivity, quality and safety outcomes of work environment. Based on previous human performance models and theories, researchers have introduced the guideline principles of "Work Compatibility Theory", which is a comprehensive quantitative approach to solving the problem of human performance outcome [1].

Work compatibility allows the assessment of workplace characteristics (including both physical and psychosocial factors) using a common metric [4]. According to the model, work-related variables can exert both a positives and a negative effect; the integration of both determines the final outcome. Also, 12 specific variables were identified as Work Compatibility Variables [2].

A mathematical model was established by Wallace et al**.,** giving an empirical solution to the Work Compatibility (WC) matrix. Based on that, an equation for WC matrix was proposed [5]. Furthermore, an operating zone was developed in which there was a region of optimality for the employee to function with good degree of efficiency. S. Salem et al. developed the W*ork Compatibility Model* (WCM) as a multidimensional diagnostic tool of human performance that measures the level of synchronization between the workforce and the work environment [6]. The authors proposed a quantitative model and a graphic-based framework to implement the work compatibility model at the operational level. Using the proposed approach, managers can identify smart solutions that contribute to personnel development.

Researchers have measured the work compatibility of different work related variables among 147 construction workers using a Demand –Energizer Instrument (DEI) [7]. In this questionnaire based study, the association between the exposure variables (work energizer and work compatibility) and outcome variables were determined using a *multivariate logistic regression model.*

In the context of industries in Bangladesh, the work compatibility variables are yet to be identified and established. The present WCM, with appropriate customization, can very well be used in this regard. There is a scope of extending the research with the use of a new tool in identifying the priority areas for future intervention strategies [7]. Since the idea behind the WCM model is based on the positive and negative effects of a web of elements and each of these elements are correlated, the application of Neural Network approach can be considered to produce a more comprehensive and holistic result [8, 9].Use of ANN for Work Compatibility Modeling can be considered for a number of reasons [10].

3. THEORETICAL BACKGROUND

Two important concepts were combined in the study, necessitating theories regarding two different concepts- Work Compatibility and Artificial Neural Networks.

3.1 Work Compatibility

Depending upon positive or negative impacts, work related factors are classified into two major categories. Variables in the work environment that positively affect the energy supplies in the human system such as financial incentives, social recognition etc. are coined as "Work energizers". Variables that negatively affect energy supplies of human system are termed as "Work Demands", e.g, work conflict, making decision etc [1]. The relationship between the positive and negative impact factors results in the important work design parameter, named Work Compatibility (WC). All individual factors in the system are integrated to produce the work compatibility. It is derived from the concept of an integrator as in control systems.

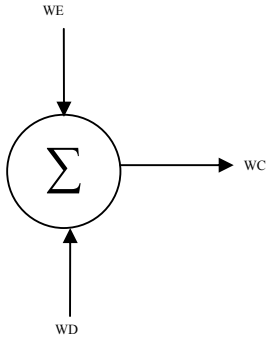

Fig 1. Work compatibility theory

Later, a mathematical model for WC was developed by Wallace et al., where WC for a particular work variable was found in the form of a matrix called the WC matrix [2]. It was a two dimensional matrix, where Work Demand (WD) was taken as row values and Work Energizer (WE) was taken as a column value, both on a 5- step scale. Thus a five- by- five matrix resulted, in which each particular position denoted the state of WC of a particular work related variable. Some contours with significant Work Compatibility characteristics were also identified in the matrix [5].

3.2 Artificial Neural Networks

Artificial neural networks, originally developed to mimic the basic biological neural systems- the human brain particularly, are composed of a number of interconnected simple processing elements called neurons or nodes [9]. Each node receives an input signal which is the "total" information from other nodes or external stimuli, processes it locally through an activation or transfer function and produces a transformed output signal to other nodes or external outputs. Collectively a number of neurons can perform a surprising number of tasks quickly and quite efficiently. This information processing characteristics makes an ANN a powerful computational device.

In the graphical presentation of a neural network, the signals are interconnected at certain points. These points are called *nodes.* An activation function or a firing rule determines the way to decide whether a neuron should fire or not for any input pattern. Most frequently, a

sigmoid function is used. Usually a network is trained by providing it with input and matching output patterns. The architecture of and ANN is very important. A *"feed forward back propagation"* network, as shown in Fig. 2, is most often used, in which there are three layers of neurons. The first or lowest layer is an *Input Layer,* where external information is received. The last or the highest layer is an *Output Layer*, where the output value is obtained. In addition to the input and output layers, one or more *Hidden Layers* may be present in these networks, comprising of a number of *Hidden Neurons.* The purpose of hidden neurons is to intervene between external input and network output so that the network in enables to reduce prediction error.

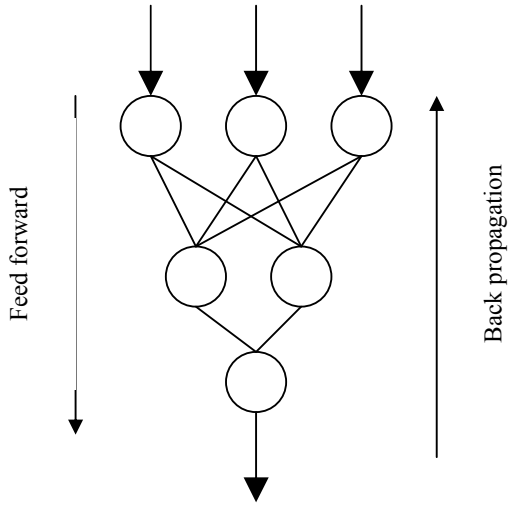

Fig 2. A feed forward back propagation neural network

4. DEVELOPMENT OF THE CONCEPT OF OVERALL WORK COMPATIBILITY

Work Compatibility is a variable- based compatibility matrix. For each work variable, there will be a different WC matrix assigning the WE and WD values of the concerned variable. From the WC matrix, an area of WC can be found.

The Overall Work Compatibility (OWC), on the other hand is a concept based on the theory of Work Compatibility, but this is a employee- specific value. For each employee, different work- related factors are rated and based on a previously trained Artificial Neural Network, the productivity of that employee is calculated. This rate of output or productivity is termed as the Overall Work Compatibility (OWC) of that employee. This is a concept where all the work related variables are integrated together to produce, not a matrix, but a single value that can be used as an indicator of work compatibility. Here, it is assumed that, the more compatible an employee is, the greater will be his/ her work productivity. The OWC, thus is expressed as work output such as pieces per unit time or hours of work done per day etc.

4.1 Methodology

The study was conducted to develop a model based on Artificial Neural Network (ANN) in order to find out the Overall Work Compatibility (OWC) of workers in a certain work environment. To analyze how compatible a work situation is for a particular worker, the work related variables were crucial. Selection of appropriate variables was very important. A representative sample of workers was selected and the data regarding all the work variables and work output were collected. By feeding the data in a computer program to analyze neural networks, a best neural network model was chosen. This was later validated with more data. The outcomes of the network were analyzed. Thus, relative importance of different work related variables were obtained.

4.2 Analysis using ANN

To develop the OWC of a particular work environment, data was taken from the production floor of an eminent garments industry of Bangladesh. Eight variables, regarded as important work related components, were chosen.

Table 1: Input and output variables and their units

		Name	**Unit**
Input variables	1	Experience Level	years
	2	Education Level	years
	3	Salary	taka
	4	Age	years
	5	Gender	(1/-1) =(Male/ Female)
	6	Difficulty level of work	Scale of 3
	7	Management's opinion about the worker	Scale of 3
	8	Worker's attitude towards management	Scale of 5
Output variable	1	Overall Work Compatibility	Pieces per hour

The 80-20 rule was used to divide the data into training set and testing set for neural network. Using different combinations of training and testing sets, a number of ANNs were developed. The best ANN was chosen based on the performance characteristic called R- Squared value. The formula for R^2 is:

$R^2 = 1- (SSE/SSyy)$,

Where $SSE = \sum(y-\hat{y})^2$, and

$SSyy = \sum(y-\acute{y})^2$,

y is the actual value, $\hat{y}$ is the predicted value of y, and $\acute{y}$ is the mean value of all y the values.

R^2 compares the accuracy of the model to the accuracy of a trivial benchmark model wherein the prediction is just the average of all of the example output values. A perfect fit would result in an R Squared value of 1, a very good fit near 1, and a poor fit near 0. The characteristics of the ANN with the best performance is presented in Table 2.

Table 2: Neural network characteristics

Number of input variables	8
Number of output variables	1
R^2 value for best network performance	0.9214
Number of hidden neurons trained	10
Optimal number of hidden neurons	10

5. RESULTS

The R- squared value of the selected ANN, as seen from above, was 0.9214, which indicated a very good fit. The ANN could be said to be a good model. Therefore, the relative importance values obtained from this model was taken as the relative importance of corresponding WC variables. Basically these values were the weights put on various WC variables in the ANN by trial and error, a combination of which produced the best fit. Table 3 depicts the relative importance values of various WC variables found from the selected ANN model.
These importances are depicted pictorially in Figure 3. In Figure 4, the actual and predicted values of the selected ANN have been shown. It is evident that the values match well, indicating that the selected model is good enough.

Table3: Relative importance of variables

Variable	**Initial**	**Relative importance obtained**
Experience	experience	0.530
Difficulty Level	dffclt lvl	0.167
Gender (Male/Female)	M/F	0.091
Managements' Opinion about	mgt's opnn	0.069
Salary	salary	0.064
Age	age	0.036
Attitude towards management	attitude twrds mgt	0.028
Education	education	0.016

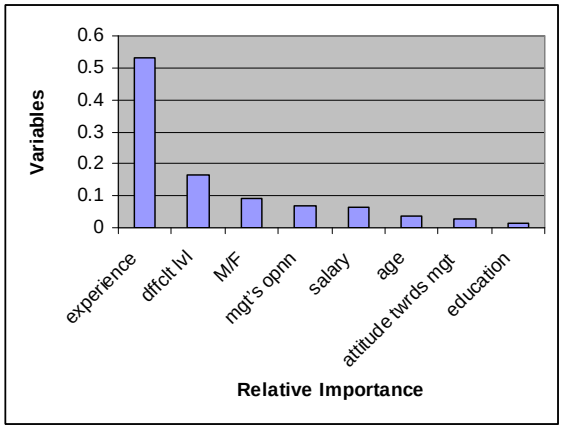

Fig 3. Relative importances of the input WC variables

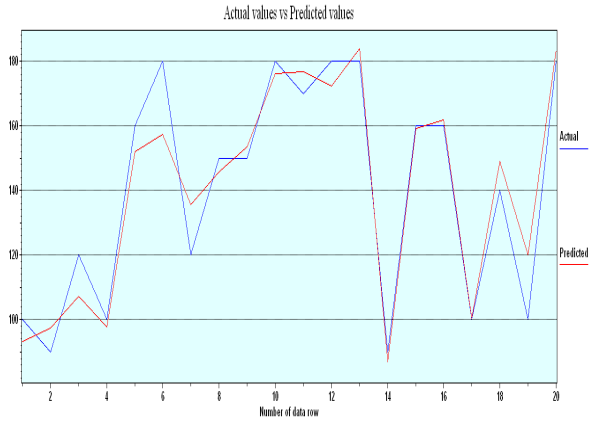

Fig 4. Prediction by the selected ANN model

As evident from the results, Experience level of workers is the factor in the particular work situation, that influenced work outcomes the most. The second most influential WC variable was difficulty Level of work. Although these comparisons may seem capricious, but the fact is, when considering their combined effects, it is very much possible that an unlikely work variable may succeed to influence more.

6. DISCUSSIONS

This analysis has been done using 10 variables that may affect Work Compatibility. These were the variables that varied most from worker to worker. Also, according to their opinion, these variables had immediate affect on work productivity. But there are many more variables, especially psychosocial ones, which could be incorporated in such analysis. Further scopes lie in that area.
It is to be kept in mind that results provided by ANN mostly depends on what it is taught with. Therefore, data integrity is a crucial factor when we are using ANN. For each worker, original data has been collected and used. But still judgmental data such as managements' rating may vary from person to person. Such trivial details were ignored.

7. CONCLUSION

Thus an ANN model can possibly be developed for a particular work situation in order to straighten the seemingly capricious and intertwined relationships among work related variables. The model would also predict output values in terms of pieces produced per hour when a future unknown situation in provided. The output thus obtained could be taken as the OWC value for that particular situation.
Future scope of further research in this field lies in exploring more work situations and work variables, and a common platform could be established.

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9. NOMENCLATURE

Symbol	Meaning
WC	Work Compatibility
OWC	Overall Work Compatibility
ANN	Artificial Neural Network

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