An Interaction Approach for System Engineer's Surrounding

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Masatoshi IDO and Toshiko FUKUMA

Abstract

The purpose of this research are 1) to construct an environmental model to hire an excellent System Engineer (SE) structured by characteristic factors concerning with information processing business and 2) to clarify the weights among these factors by using path analysis. These factors were selected by the method of job analysis and the brain storming based on the survey of 226 information processing business organizations

This causal model was constructed from five factors obtained by brainstorming, in that factors vocational aptitude test, personal character, entrance examination for organization, educational history and job attitude are included. The fresh 80 employee's data of six organizations were used to this model. In the result it becomes obvious that the most effective factor to job attitude is vocational aptitude.

For the information business organizations it will be useful to choose the excellent SE from the new occupation applicants by the control of these factor's weights.

1. Introduction

The development of information processing business has brought us a high technical systematic society, and the computers are deeply concerned to our daily life. The ministry labor of Japan had shown in the survey of the state of service business in 1986, the number of the organizations are 2,808 of which ratio increases 60% compare with one in 1980. The number of the employee of such information business is 198,522 in 1986 that is about twice of 93,271 in 1980. Among these employees programmer and system engineer (S. E) are increased most, the former ratio is grown up from 21.4% in 1980 to 30.4% in 1986 and the latter ratio is also grown up from 14.7% in 1980 to 24.2% in 1986 (Fig. 1).

Rapid development of this business has resulted in increasing to extend various markets for organization's managers, and created additional labor inputs. Such information processing organizations require the new employees frequently, but enables them to keep a sufficient number of employees as they first arranged, because of the shortage of this occupationnal candidate. The managers want to hire the under graduate students of college and the major which the students studied in their college is not only in the engineering or science but also in all the field. Even though the managers are aware of the difficulties of hiring new employees who have sufficient skills and abilities, they applied the vocational aptitude test for new candidates. The more useful method will be needed for these organizations.
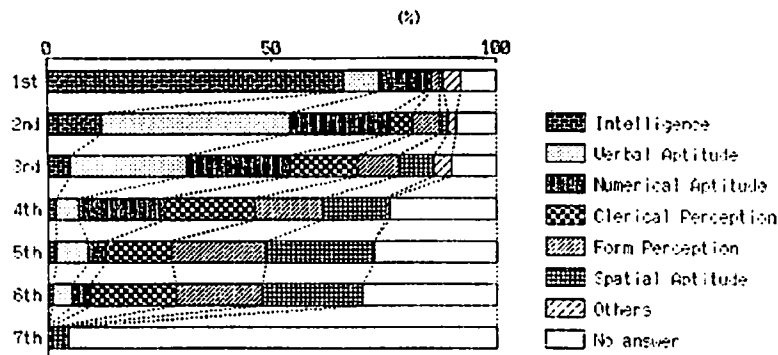
Fig. 1　Rapid increasing of the emploees of information processing Organizations

2.　The problem of vocational aptitude

As the job of System Engineer is comparably new kind of occupotion the name and the main jobs are not defined clearly. Under such unfortunate conditions the vocational aptitude has not been investigated sufficiently. In general the vocational aptitude required for SE can obtain by analyzing objective job, however, it is difficult to identify the aptitude with SE's one.

3.　The frame of the survey

The survey will be helpful to know the actual condition of information proceessing organizations[1]. The questionnaire method by mail was applied for the 506 organizations. and the ratio of returns was 44.7%. The organizations were selected under the conditions in which applied vocational aptitude test for hiring system engineer. The questionnaire sheets were sent on June 25 in 1987, and the dead line of the answer sheets was July 10.

In the survey 31 main questions and 23 additional questions are included. They are clustered into two parts, one is constructed by six items of which answers are formed by multiple choice as following,

(A)　The hiring condition of system engineer

(B)　The hiring method of system engineer

(C)　About the vocational aptitude that the organization are applying

(D)　The employee's ability and job attitude after hired

(E)　The training course of system engineer

(F)　The main job of system engineer

and the another is constructed from five items of which answers are formed by free notation as following.

(1)　the definition of the system engineer

(2)　the main job of system engineer

(3)　the problem of the vocational aptitude

(4) the verification by the applied vocational aptitude test

(5) the aptitude needed for system engineer

4. The result of the survey

The 226 organizations answered in a limited interval, and the ratio of return was 44.7%. The scale of the organizations classified by the number of the employees are shown: Fig. 2.
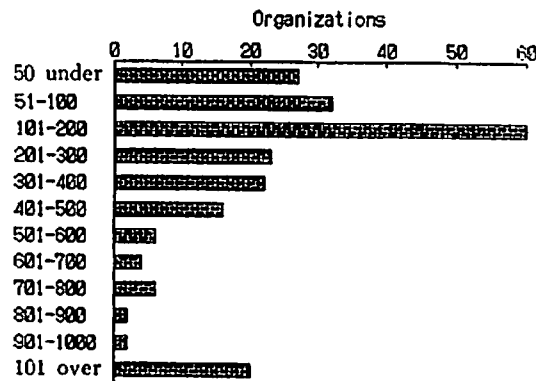

Fig. 2　The management scale classified by the number of employees

Most information processing organizations can be characterized by small managing scale.

The ratio of the organizations applied the vocational aptitude test for new employee(SE) were 90.3%. With using other methods such as interview (98.2%), testing the general education (43%), checking the personnal character (31.0%), and making the essay (31.0%), the new employee (SE) will be selected. The 34.5% organizations replied that they are developing the own vocational aptitude test by themselves, and others replied that they are using the common test published in specific organizations etc. (Fig. 3).

5. The problem organizations having

The managers of organizations consider that System Engineer is the central issue among various kind of workers concerned with information processing. Unfortunately they suggested the difficulties of hiring new employees. Only the 30% organizations answered that they could
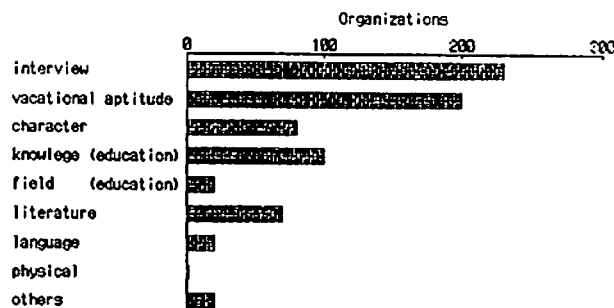

Fig. 3　The test that organizations applied for candidates

get enough number of employees as they were arranged first, others answered that they could not help hiring with insufficient conditions to fill the first plan. These conditions work all the time, it becomes a problem such as employees attitude toward turnover, absenteeism, retire and so on. Within a years 45% organizations experienced the employee's turnover. Although the 38.4% of the turnovers answered that the reason are depend on individuality, 23.2% answered that they had not enough ability or vocational aptitude as system engineer. The 19.2% were not attracted in the job, and 8.6% answered that the personnel character were not adjustable to the job.
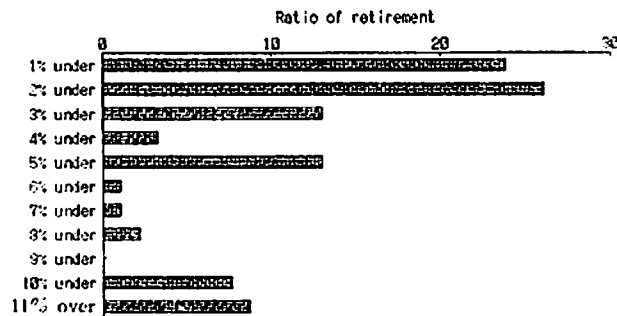

Fig. 4 The ratio of the new employee's retirement in the last three years

From the organizational point of view, the reduction of such redundant labor costs is very important for economical management. The improving of the vocational aptitude test will be needed.

Some organizations pointed the learning effectiveness of the vocational aptitude test by retiring by the candidates, because the very common test has given. They are not always satisfy in the test they are using because of the unreliability and the insufficient.

6. The new vocational aptitude test

In an effort to improve these problems above written, it is essential to develop the new vocational aptitude test. For the general aptitude of the test battery. The ministry of labor of Japan has shown that the important factors in the plot type groups of job for system engineers are I-N-S, ranked by the order of importance[3]. By this survey, it is interesting to suggest that the major contributing factors (in which the ordering is changed) to the

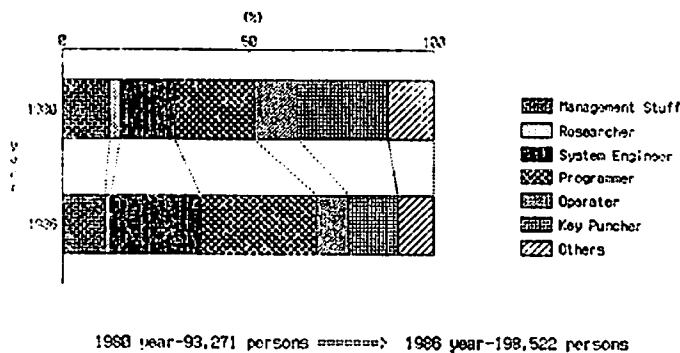1980 year-93,271 persons ========> 1986 year-198,522 persons

Fig. 5 The order of the importance of Vocational Aptitude (GATB)

high rate of adjusting for vocational aptitude are I-V-N, and S is ordered lower level.*
(Fig. 5)

Referring the result of survey, the new vocational aptitude test was developed[3]~[4].

*I: Intelligence,　N: Numerical Aptitude,　V: Verbal Aptitude,　S: Spatial Aptitude

7. The needs of new hiring method

The sum of the ideas from a group of people operating together should exceed the total number of ideas the same people could generate operating individually. The authors and the managers of the five organizations who desired to improve such insufficient conditions associated on the brainstorming. The result shown in Fig. 6.
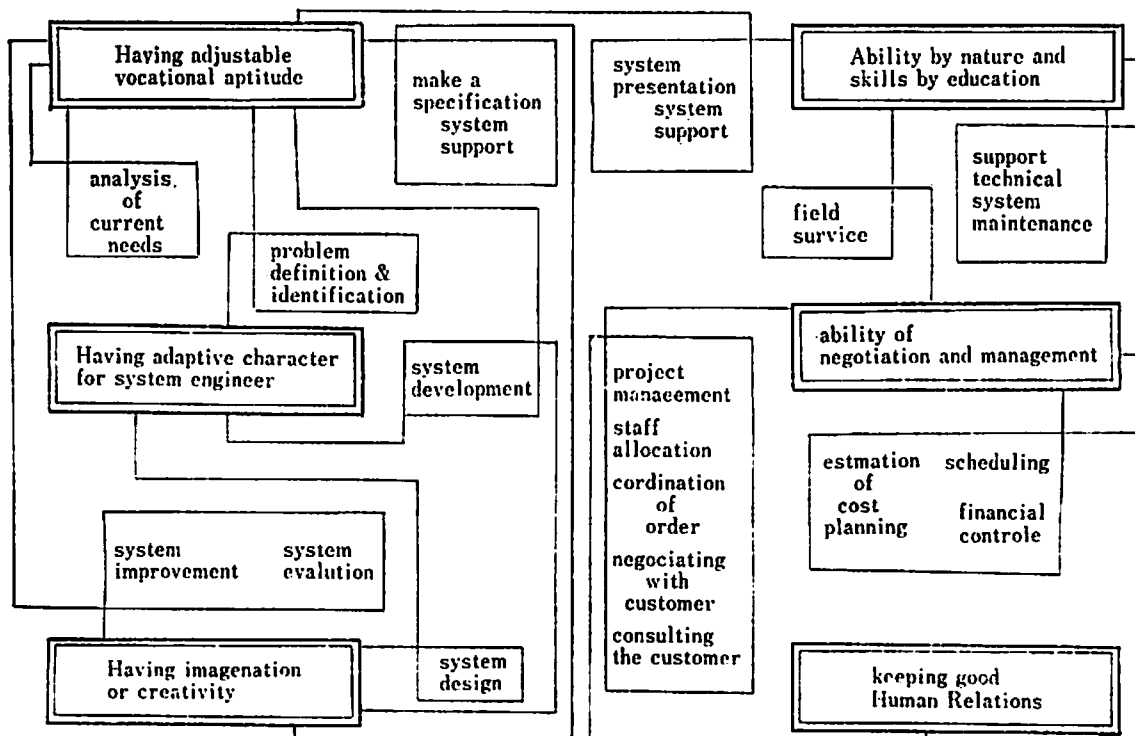

Fig. 6　The brainstorming schematics.
Relation factors reduced are written in the rectangles

Some important factors which are closely related to the job of system engineer are indicated to that model by the method of brainstorming as following:

1) Having adjustable vocational aptitude

2) Having adaptive personnel character for system engineer

3) Ability by nature and skills by education

4) Keeping good Human Relations

5) Having imagination or creativity

6) Ability of negotiation and management

8. Making the path diagram using causal analysis

The causal analysis has been developed mainly in the field of sociology, and two procedures have been suggested to determine the causal relations. The one is by Blalock[5], he constructed the causal model and evaluated the adjacency. The another is path analysis by Boudon[6], to that model he calculated the weights of the causal relations. The method is one for dealing with a system of interrelated variables. It is based on the construction of a qualitative diagram in which every included variable measured is represented (by arrows). Each factor in a diagram is connected by lines with arrowheads at both ends with each of the other factors to indicate possible correlation except in cases in which it can safely be assumed that there is no correlation. It can be applied to mathematical systems of linear relations.

9. The structure of a system

Consider $p+q$ quantities where n_1, n_2, $\cdots\cdots$, n_p and e_a, e_b, $\cdots\cdots$, e_q are measurable and p causal relations determine the n's, absolutely and uniquely by the e's. The equations which express these causal interrelations are

$$n_1 = F_1(e_a, e_b, \cdots, e_q; a_{11}, a_{12}, \cdots, a_{1k})$$
$$n_2 = F_2(e_a, e_b, \cdots, e_q; a_{21}, a_{22}, \cdots, a_{2k})$$
$$\cdots\cdots\cdots \qquad \cdots\cdots\cdots \qquad\qquad 1)$$
$$\cdots\cdots\cdots \qquad \cdots\cdots\cdots$$
$$n_p = F_p(e_a, e_b, \cdots, e_q; a_{p1}, a_{p2}, \cdots, a_{pk}).$$

Each variables n is assumed to be caused by the set of e-variables. The variable k is depend on the allowhead. The parameters denoted by a are constant depend on the model. Consider the variables subject to random noises. Random noises enters into the e's as response error. By extending measured n's and e's suppose the quantities y's and x's which satisfy the error equations as following:

$$y_i = n_i + w_i \qquad (i=1, 2, \cdots, p)$$
$$x_j = e_j + d_j \qquad (j=a, b, \cdots, q) \qquad\qquad 2)$$

where w's and d's are distributed independently of the n's and e's. The means of these errors are assumed to zero. The e's and n's are not courted with errors, however each observable quantity (x or y) is corrected with its own error. By solving the structural equations 1) and the error epvations 2) to eliminate the n and e variables, the model eqvations can be obtained as following:

$$y_i = F_i(x_a - d_a, x_b - d_b, \cdots, x_q - d_q, a_{i1}, a_{i2}, \cdots, a_{ik}) \qquad\qquad 3)$$
$$(i=1, 2, \cdots, p)$$

The a-parameters can be e estimated from equation 3).

Suppose the closed causal system consisting of q primary factors or causes (e's) and p resultant effects (n's). These $p+q$ variables may then be considered to be associated one with another by a network of causal path ways.

The following conditions are assumed to hold for this system.

(1) $x_j=e_j$ for all j (errors in x are negligible).

(2) $y_i=n_i+w_i$ for all i (errors in y are additive). 　　　　　　　4)

(3) w_i are normally distributed with mean zero and variance 1 for all i.

(4) w_i are uncorrelated one with another for fixed i and from variable to variable.

(5) w_i are uncorrelated with x_j for all i and j.

10. The environmental model using the factors obtained from brainstorming

It is useful to make a path diagrams to know the effects among the characteristic factors of SE have and is important to know the behavior of factors[7~9]. By the brain storming, four causal factor groups and one resultant factor group were obtained from the five information processing organizations as plot-type as shown in table 1.

Table 1. Causal and resultant factors.

factor	variable		
causal	n_1: vocational aptitude test	(problem 1···7)	
	$e_a(n_2)$: personal character	(type 1···4)	
	n_3: education	(kind 1···3)	
	n_4: entrance examination	(kind 1···3)	
resultant	n_5: job attitude	(kind 1···4)	

The diagram under the model is one in which a variable n_5 is represented as completely determined by a number of immediate factors n_1, n_2, n_3, n_4. As all relations are assumed to be linear, n_1, n_2, etc. can be shown as following (structural equations);

$$n_1=a_1+a_{1a}\cdot e_a$$
$$n_2=e_a$$
$$n_3=a_3+a_{3a}\cdot e_a+a_{31}\cdot n_1$$
$$n_4=a_4+a_{43}\cdot n_3+a_{41}\cdot n_1$$
$$n_5=a_5+a_{5a}\cdot e_a+a_{51}\cdot n_1+a_{53}\cdot n_3+a_{54}\cdot n_4$$

5)

The coefficients a_1, a_{1a}, etc. are of the type of partial regression coefficients and are defined as a path regression coefficient.

The path daigram for this madel is:
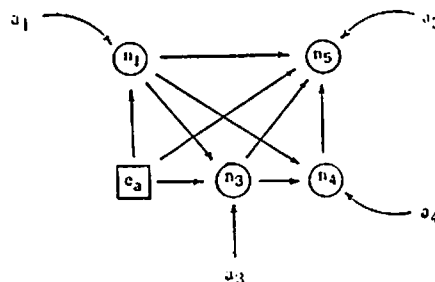
The model equations can be obtained by substitution from the error equations as following:

$$y_1 = n_1 + w_1$$
$$y_3 = n_3 + w_3$$
$$y_4 = n_4 + w_4 \quad\quad 6)$$
$$y_5 = n_5 + w_5$$

11. Data of this model

The data used in this model were obtained on November in 1987 as follows. The objective organizations are five from which the fresh 80 employees (SE) are selected as sampling data. In the investigations the score of entrance examination to organization, the score of vocational aptitude test, the check of personal character and the educational history are included. The variable n_1 is a vocational aptitude test score and is chosen from the group of which members are consist from seven vocational aptitude test problems so as to meet the order of importance. Intelligence could be measured by using the problem. The variable n_2 is the score of characteristic test selected as same manner as n_1. Educational score n_3 was calculated by the average of number of A(indicate most excellent degree). The variable n_4 is the score of a entrance examination for the organization. The resultant variabl n_4 is the score of a entrance examination for the organization. The resultant variable n_5 was obtained by checking a job attitude of the candidate after 6 months since he/she get a job.

12. The result and verification of the models

By calculating equations[6], pass regression coefficients can be obtained. The diagram with path regression coefficient included variables are as shown Fig. 7.

The path coefficients in a parenthesis indicate the relations under common vocational aptitude test of which the organizations had been used. It is interesting that the path coefficient between n_1 and n_5 idicates reasonable value under new vocational aptitude test that has developed in this study which depend on the survey as mentioned above and ap-

Fig. 7 The path diagram constructed from six factors.
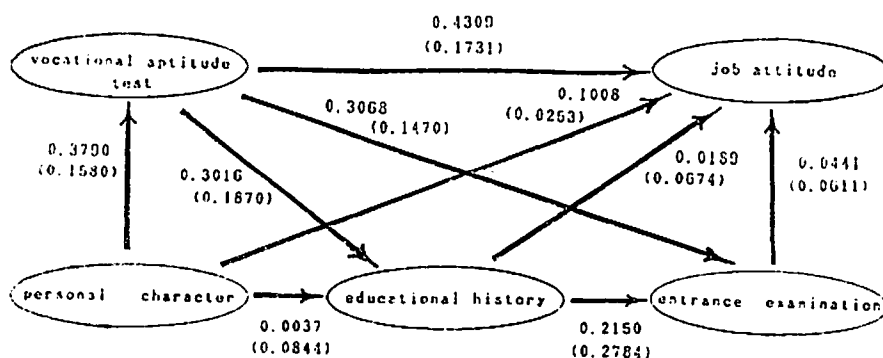
plied for the first time. Learning effect by candidate will be included in a common test because the style is too popular. The path coefficient between n_1 and n_5 is not so reasonable as the organizations pointed out at first. The work environment and human relation are more important for the labor motivation. The variable n_4 which indicates the entrance examination for organization is also one of controllable factor in this environmental model, however, it does not have deep concern with n_3 and n_5.

13. Conclusion

The 506 information business organizations (in which the ratio of returns was 44.7%) in this survey, and the ratio of the organizations who applied the vocational aptitude test for new employee were 90.3%. Unfortunately the managers suggested that they are not sufficient of the test they are using, and pointed out the needs of studying and developing more functional vocational aptitude test. Only the 30% organizations replied that they make their own test for new candidates. Through this study it was obvious that the variable n_1 (belongs to vocational aptitude test) behaves effectively to the job attitude.

This is one of the plot-type model in which each variable such as vocational aptitude test problem (3) is selected as a critical causal factor. Any other model constructed depend on the desired variables to estimate a path coefficients is available in this study. For selecting the variables corresponded the factors, carefully attention must be provided. The useful causal-and-resultant process can be modeled; for example, changing the variable in a group depend on a factor such as vocational aptitude problem or personal characteristics etc. All that is needed, in these situations, is sufficient research effort of relations among the variables.

If the organization's manager, who wants to improve the hiring system of the new employee, by applying this causal model, the states will become better. However, they must be care for developing or using the new vocational aptitude test. The enough study for the test battery will be need.

The new vocational aptitude test developed in this study that was made based on the survey in which problems were more complicate and difficult than common ones was behaved with interested enough. The additional efforts of studying and developing for the vocational aptitude test battery will be promoted.

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