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MODEL FOR EVALUATION OF THE EFFECTIVENESS OF TRAINING OF HUMAN RESOURCES

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Abstract: Evaluation of the effectiveness of personnel training is important for improving the process of training and for the successful activity of the organization. This article presents a model for evaluating the effectiveness of the training. The statistical hypothesis on improving the practical skills of workers after training has been verified. The influence of satisfaction with training on their productivity has been studied. A mathematical model of the study is presented and is developed a program in Java Script with arrays to accelerate and optimize the procedure of effectiveness assessment.

Key Words: Staff training, Java script, hypothesis, t-test, dispersion analysis

1. Introduction

The popularity of the application of mathematical and statistical methods in management is increasing, but their practical realization in Bulgarian enterprises is unsatisfactory. Leaders of many organizations mistakenly adopt mathematical and statistical methods, and tools intended for technicians and analysts. Senior management who is interested in continuously improving the efficiency and competitiveness of the organization, to improve the quality of processes and products should also own and apply in its activities mathematical and statistical thinking.

Evaluation of the effectiveness of professional training in the organization is one of the most important tasks in the management of personnel. Training costs are considered an investment in human resources. They must bring the organization's

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return - increased efficiency, profit growth, full realization of the objectives. Costs of material, time and human resources associated with the preparation and implementation of professional training are justified only when training helps to increase the knowledge and skills necessary for successful labor performance [1].

The question of assessing the effectiveness of staff training causes many issues both in theory and in practice. The evaluation process is related to some methodological difficulties and the assessment in most cases can only be approximate. These difficulties (especially in Bulgarian enterprises) are connected with the undeveloped methodological issues, the absence of an established and probated legal basis for accounting the economic efficiency [2], [3], [4]. However, the most commonly used models for assessing the effectiveness of training in practice are those based on the models of D. Kirkpatrick, J. Phillips and others. [5], [6]. These models describe the process of evaluating the effectiveness of training in the following aspects:

- Evaluate the satisfaction of trainees;
- Improving knowledge;
- Evaluation of the change in the behavior of students;
- Increase productivity, improve performance, increase sales;
- Return On Investment.

This article studies the link between improving the knowledge and skills as a result of training and the relationship between satisfaction with training and labor productivity in the furniture business. The methods of statistical hypothesis are applied: t-Student [7] test for dependent samples and dispersion analysis.

The hypothesis is scientific assumption derived from theory not yet confirmed or rejected. Importance of practice have the statistical hypotheses which represent confirmation regarding an unknown parameter defined by mathematical statistics. During the organization of the experiment hypotheses are limited to 2: primary and alternate. The experimental hypothesis serves to the organization and for conduction of the experiment, and statistical to carry out the procedures on comparison of the recorded parameters. Statistical hypothesis is necessary for the mathematical interpretation of the data from the empirical studies. The experimental hypothesis is primary, and statistical - secondary. The experiment is conducted in specially controlled environment to verify the experimental hypothesis about a specific cause and effect link.

2. Evaluating the Effectiveness of Training

In order to assess the effectiveness of personnel training in a furniture company has been verified have improved the practical skills of workers after training and ex-

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plored the relationship between satisfaction with training and productivity of trained workers. The experiment was conducted in two steps:

Step 1: Evaluation of training. After training of workers in the furniture factory was suggested that practical skills of employees increased as a result of the training. Applied is the method of verifying the hypothesis - t-test of two dependent samples. Depends samples are which units of the first sample predetermine those in the second. A typical case is both research and analysis when comparing variables before and after some impact.

The experiment is correct, as trained workers from the first and the second study are the same. Conducted was a three day training of workers of furniture company in connection with the implementation of production of new models of furniture with existing technology in the process. In order to determine the effectiveness of training and to assess the practical skills of workers was made practical test assessing 10 key skills in the work of the participants. The maximum number of test points is 10 and the minimum number is 0. An random sample of 15 trained workers with results before and after the training, are presented in Table 1 and is selected probability of error $\alpha = 5\%$.

1. Formulation of null and alternative hypothesis.

Under the null hypothesis H0 is assumed that there is no difference in compared statistic metrics and if empirical data have differences, they are the result of random factors.

The alternative hypothesis H1 is that the observed differences in empirical data are the result of logically relevant factors, ie, that a three-day staff training help increase the test results of workers.

2. Selection of appropriate criterion to verify the hypothesis. In order to select a suitable criterion to verify the hypothesis is necessary to know the conditions that must comply the variables, number and type of samples and more. Suitable for the experiment, is t-criterion of Student for dependent samples in which:

- Indicators are quantifiable.
- Have a normal distribution.
- Two samples are dependent

3. Calculation of the empirical value of the criterion (temp).

The process of calculating the temp is performed in several steps (Tab. 1).

The differences in the results of both tests are identified by Di and the the average difference is calculated as an arithmetic average by the formula:

$$\overline{D} = \frac{1}{n}\sum_{i=1}^{n} D_i = -1.93.$$

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Employee	Score before training	Score after training	D_i	$(D_i - \overline{D})^2$
	A_i	B_i	$A_i - B_i$	
1	5	7	-2	0.005
2	7	8	-1	0.865
3	7	9	-2	0.005
4	5	5	0	3.725
5	3	5	-2	0.005
6	7	8	-1	0.865
7	6	7	-1	0.865
8	5	9	-4	4.285
9	5	9	-4	4.285
10	4	8	-4	4.285
11	5	7	-2	0.005
12	4	5	-1	0.865
13	6	5	1	8.585
14	7	9	-2	0.005
15	5	9	-4	4.285
Total			-29	32.935

Table 1: Results of the practical test of workers as a result of training

The evaluation of the standard deviation σ is calculated as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(D_i - \overline{D})^2}{n-1}} = 1.53.$$

The standard error SE shall be calculated as follows:

$$SE = \frac{\sigma}{\sqrt{n}} = 0.40.$$

Empirical characteristic to verify hypotheses (temp) is obtained as:

$$t_{emp} = \frac{\overline{D}}{SE} = -4.825.$$

4.Determination of the tabulated value of criterion (t_t).

The tabulated value of the criterion t_t depends on the degrees of freedom k and the level of significance α. The statistical table for t-distribution of Student find dependent from α and the degrees of freedom df, critical value $t_{\alpha,df}$. For $\alpha = 5\%$ (with a one-sided critical area) and $df = 15 - 1 = 14$ we receive $t_{0,05,14} = 1.761$.

5.Decision making. For this purpose the tabulated value of the criterion is compared to the empirical (calculated according to data of the sample) and accordingly concluded which of hypotheses (the null or alternative) is correct.

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- If the empirical value is less than the tabular for true is accepted the null hypothesis (H0).
- If the empirical value is greater or equal to the the tabular - the null hypothesis (H0) is rejected and is considered a true the alternative hypothesis (H1).

Comparing the calculated value of for t_{emp} and critical value $t_{\alpha,df}$. The null hypothesis is rejected because $|t_{emp}| > 1,761$.

Conclusion: The difference in results between the two tests can be considered statistically significant, that is, with a confidence level of 95%, we can say that introduced curriculum has had a positive impact on test results.

Step 2: Exploring the relationship between satisfaction with a training and performance. With the same workers was conducted a survey on satisfaction with the training and were collected data on labor productivity for 1 month. The responses of the surveyed workers according to the evaluation of training are grouped into three groups (Table 2). It is necessary to establish whether the differing assessment of satisfaction with the training is related to the level of labor productivity of workers.

№	Group of workers in training evaluation	Number of orders for 1 month	Number of workers in group	Average production of 1 worker
	x_i	y_{ij}	n_i	$\overline{y_i}$
1.	Good	7, 12, 11, 9	4	10
2.	Very good	7, 14, 15, 17, 18, 19	6	15
3.	Excellent	21, 17, 20, 21, 19	5	20
	Total		15	

Table 2: Grouping of workers according to the evaluation of training and productivity

A convenient method for analysis is one-way ANOVA. The significance level was defined as $a = 0.05$.

In order the calculation procedure to be accelerated and optimized was developed a Java Script program. Parts of the code that implements the program is presented in listing 1. The program is implemented through arrays. We created a function that finds the sum of the elements of the array, and then average values are calculated as the sum is divided by the number of elements of the array. We compare the Fem and Ft, with the result depending on whether the criterion is met.

```
var  good = [7  , 12, 11, 9];
```

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```
var vgood = [7 , 14, 15, 17, 18, 19];
var excel = [21, 17, 20, 21, 19];

var calcsum = function (arr) {
        var i, sum;
        for (i = 0; i < arr.length; i++ ) {
                sum += arr[i];
        }
        return sum;
}

var  sgood = calcsum(good);
var svgood = calcsum(vgood);
var sexcel = calcsum(excel);

var  avgood =  sgood / good .length;
var avvgood = svgood / vgood.length;
var avexcel = sexcel / excel.length;

var avg =  ( sgood + svgood + sexcel ) /
           ( good .length + vgood.length + excel.length );

var ssm1 = Math.pow(avgood  - avg, 2) * good.length +
            Math.pow(avvgood - avg, 2) * vgood.length +
            Math.pow(avexcel - avg, 2) * excel.length;
...

if (Femp > Ft) {
        console.log('H1 trust');
} else {
        console.log('H0 trust');
}
```

1. Listing of the code of the program to verify the hypothesis

The program can work with other values of the elements of the array, and thereby can be solved other similar tasks.

The mathematical model of the solution goes through the following steps, and after each stage are presented and the obtained results as a result of program execution: The program can work with other values of the elements of the array, and thereby can be solved other similar tasks.

The mathematical model of the solution goes through the following steps, and after each stage are presented and the obtained results as a result of program execution:

1. Definition of null and alternative hypothesis [8], [9]:
H_0 - satisfaction of employees the training provided does not have naturally impact on the level of labor productivity.
H_1 - Differences in the assessment of the satisfaction of workers from the training naturally affect the level of labor productivity.

2. Selection of method - ANOVA. Examined is the correlation between the two phenomena as the result phenomenon of cosequense is represented by varieties of attribute in an interval scale, and the other phenomenon - on the weak scale of

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measurement.

3. The evaluation of empirical characteristic is determined by the formula

$$F_{em} = \frac{\sigma_1^2}{\sigma_2^2},$$

where σ_1^2 - is the inter group deviation, σ_1^2 - Intra group deviation.

3.1. Calculation of the necessary assessments with data from Table. 2.

3.2. Arithmetic totals of groups means are obtained as the values of the resulted attribute in each group is divided by the number of cases in the group. Mean arithmetic of data groups are presented in Table 2.

$$\overline{y_i} = \frac{\sum_{j=1}^{n} y_{ij}}{n}.$$

3.3. The estimation of the average level of productivity of all observed workers is obtained by the formula

$$\overline{y} = \frac{\sum_{i=1}^{k} \sum_{j=1}^{n_i}}{n} = 15.13.$$

3.4. The evaluation of is the inter group deviation SS1 and SS2 and intra group deviation is determined by the following formulas:

$$SS_1 = \sum (\overline{y_i} - \overline{y})^2 . n_i,$$

$$SS_1 = (\overline{y_1} - \overline{y})^2 . n_1 + (\overline{y_2} - \overline{y})^2 . n_2 + (\overline{y_3} - \overline{y})^2 . n_3 = 225,$$

$$SS_2 = \sum_{i}^{k} \sum_{j}^{n_j} (y_{ij} - \overline{y_i})^2 = 121.$$

3.5. Determination of degrees of freedom

$$f1 = k - 1 = 3 - 1 = 2,$$

$$f2 = n - k = 15 - 3 = 12.$$

3.6. Evaluation of total dispersion on the basis of the inter group and intra group deviation:

$$\sigma_1^2 = \frac{SS_1}{f_1} = 112.5,$$

$$\sigma_2^2 = \frac{SS_2}{f_2} = 19.67.$$

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3.7. Estimation of the empirical characteristics of the hypothesis

$$F_{em} = \frac{\sigma_1^2}{\sigma_2^2} = 5.72.$$

4. Determination of the critical area [10]

$$F_t = \begin{bmatrix} \alpha = 0.05 \\ f_1 = 2 \\ f_2 = 12 \end{bmatrix} = 3.88,$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(D_i - \overline{D})^2}{n-1}} = 1.53.$$

5. Making the decision. We compare the the empirical and theoretical characteristics of the hypothesis

$$F_{em} > F_t,$$

$$5.72 > 3.88.$$

Conclusions: In the accepted level of significance a = 0.05 (5% risk of error) shall be rejected the null hypothesis in favor of alternative and to accept that the level of satisfaction of employees with the training has a statistically significant impact on the level of labor productivity.

The strength of the studied relation is estimated by the coefficient of correlation by the formula

$$\eta = \sqrt{\frac{SS_1}{SS_{total}}} = 81\%,$$

where

$$SS_{total} = SS_1 + SS_2.$$

is the total dispersion, i.e. 81% of the differences in the level of productivity of workers are determined by differences in satisfaction with the provided training.

3. Conclusion

Staff training is one of the most important tools for development of organizations. Improvement of professional skills of employees help increase the efficiency and quality of their work, better work performance and better results at work. Staff training is seen as an investment in human resources and should yield returns and profits for the organization. Effectiveness of training is evaluated in quantitative indicators, but can be measured in the long term and by qualitative indicators (for example, increased satisfaction of staff, the image of the organization, etc.). In all organizations assessment of the effectiveness of the training should be done with professional tools, by skilled specialists with the help of precise quantitative and qualitative indicators.

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