Quantitative Assessment Personnel Training Efficiency in Management of Radioactive Waste

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ABSTRACT

This paper describes quantitative parameters of training efficiency for the personnel working in the area of radioactive waste management. We formulate the basis for the independent parameters of an integrated training process. It is shown that training efficiency can be described by a characteristic numerical figure, which is the generalized mark of the training efficiency.

INTRODUCTION

The IAEA technical document [1] describes the assessment procedures for training efficiency of personnel working at radiation-hazardous facilities. The International Training Centre (IETC) at Moscow State Unitary Enterprise Scientific and Industrial Association "Radon" was established in 1997 for the purpose to training personnel working in management of radioactive waste [2]. The IETC develops novel methods to assess training efficiency carried out in the area of radioactive waste management. Training process is exclusively the object of investigation in this case. It is necessary to find out most important characteristic parameters which do describe this object. The purpose of our investigation is to find out interconnections between the parameters and the efficiency of training activities.

EFFICIENCY CRITERIA

The main features that describe training efficiency are as follows:

1) Level of personnel knowledge achieved
2) Level of personnel satisfaction.

These parameters are qualitative. The quantitative analysis should be based on mathematical methods which use correlation analysis of the qualitative features. The efficiency of education is based on three-level system: "satisfactory", "good" and "excellent", which can be numerically characterized by marks 3, 4 and 5. When marking the results of a training activity in a group of N participants we do obtain a characteristic mark distribution. The number *N* usually exceeds 10 and can be up to 30. The mark distribution is described by a distribution function. This function describes the probability that the mark is not less than a certain prescribed value. Distribution functions can be used to calculate necessary parameters of the system. For example we do calculate the mean mark value in a given group of participants.

Criterion I. The probability that an average mark will be nil in a group is very small. The probability that an average mark will be very high in a group is very small as well. Therefore there is the maximum probability that the mark will be equal to a certain so-called mode value. In other words the mode mark is the most often occurring value of mark. Two assessments are carried out: at the beginning of training course (Primary test) and at the end of it (Last test). As a rule at the start of training course the mode mark is relatively small. In the case of an effective training course the mode mark becomes higher, which is observed by distribution function of the end of course testing marks. Fig. 1 illustrates changes in the distribution functions and mode marks of a training course carried out at the IETC.

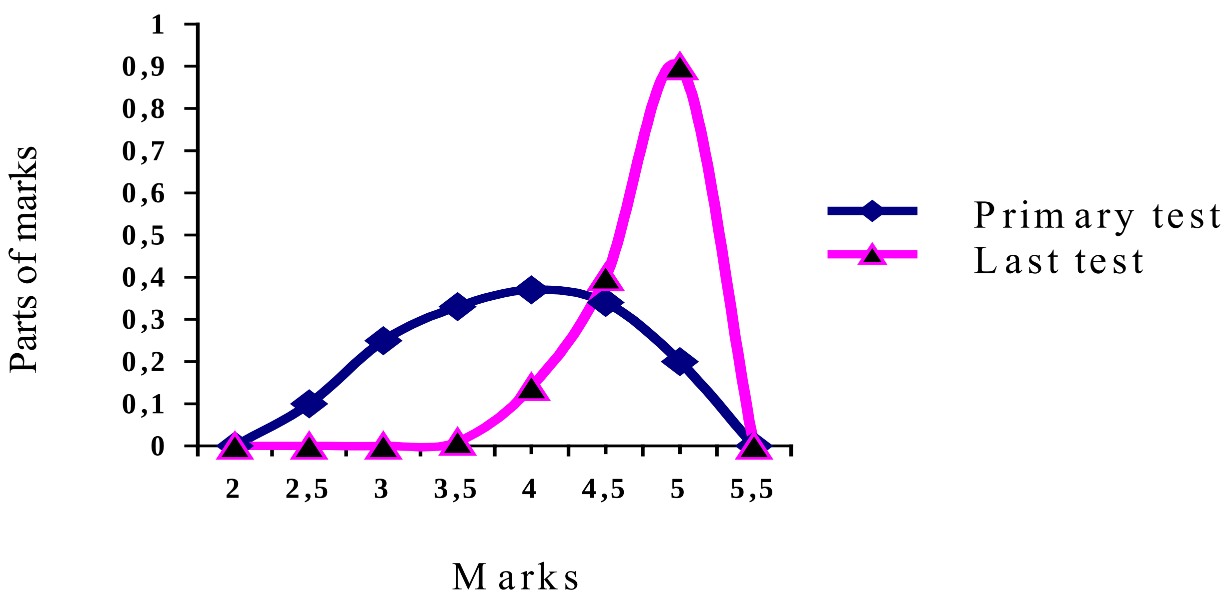

Fig. 1. Mark distribution functions for the primary and last test of IETC training course

Criterion II. In addition to the mode mark there is a dispersion of marks, σ, which characterizes the scatter of marks around the mean mark value. This parameter also characterizes training efficiency. Indeed attendees of training courses do have diverse education levels as well as diverse operational experience at the beginning of training course. Because of this at the beginning of a training course the mark dispersions σ^{in} is very high. In contrast at the end of training course the mark dispersions σ^{end} is relatively small. This demonstrates that practically all participants digested the knowledge offered to an approximately equal extent. In the case when the mark dispersion is high at the end of a training course it follows that the training efficiency is relatively small. The more efficient a training course the denser marks scatter near a large mean value. This conclusion is shown in Fig. 1. where the end of course distribution function becomes much narrower comparing the initial one with a larger average mean mark.

Criterion III. Define the distribution density of a numerical value $\Delta = b^{last} - b^{prim}$, where b^{last} is the mark obtained in the end of course (Last test) and the b^{prim} is the mark at the beginning of training course (Primary test) of a participant. This parameter is another criterion of the training efficiency. As the knowledge assessment is carried out in the framework of three-mark system parameter Δ can be equal to -2, -1, 0, 1 and 2. Training efficiency achieved in a training course can be characterized by the mean value of Δ: when $\Delta_{mean} > 0$ the training process is efficient. The higher Δ_{mean} the higher training efficiency, moreover the highest efficiency is when $\Delta_{mean} \rightarrow 2$. Fig. 2. shows distribution densities (Δ) at several training courses carried out at IETC in 2000-2004.

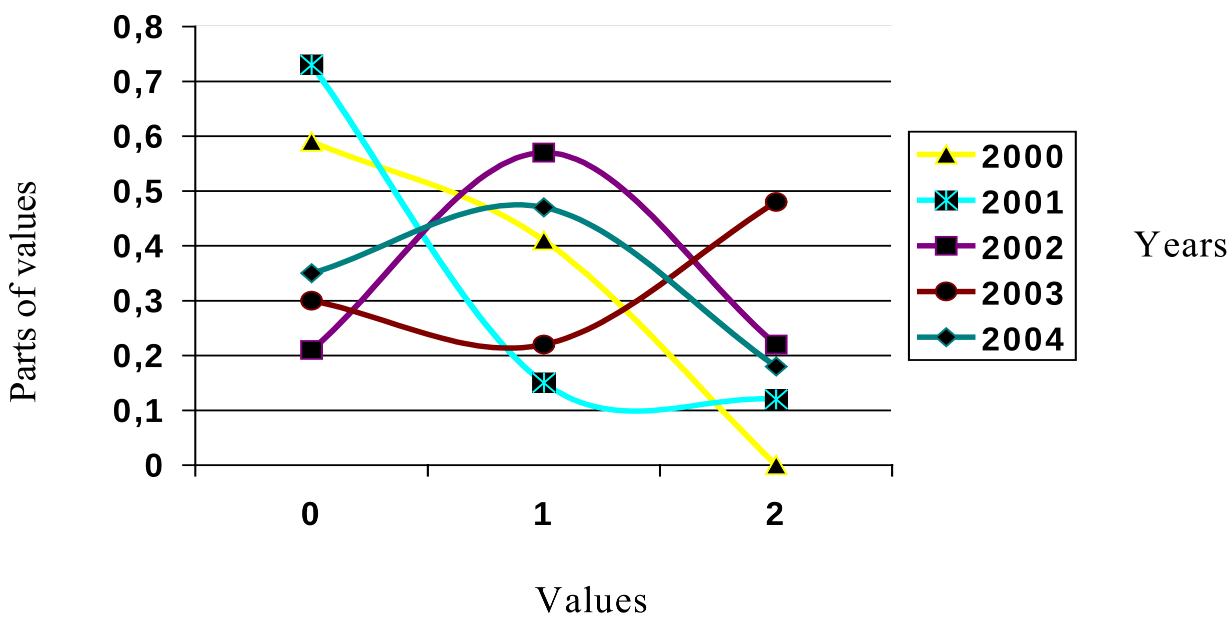

Fig. 2. Distribution densities at IETC training courses

Criterion IV. In principle the grade of the attendee's satisfaction b^{sat} is also a training efficiency criterion. Participants' satisfaction can be assessed using anonymous questionnaires containing questions such as: "*What kind of assessment you would like give for passed training course?* (*"satisfactory", "good", "excellent"*). If the percentage of answers "good" and "excellent" exceeds 70% the training course can be considered as an efficient one. This occurs when the mean value of marks b^{sat}_{mean} exceed 4.0.

INDEPENCES OF CRITERIA

The consistency of estimations using above described criteria should be based on the proof of their mutual independence. In our case it is necessary to show that the knowledge level is independent on the participants' satisfaction level.

The pair correlations between the first and second efficiency criteria as well as between the third and fourth efficiency criteria are negligible small. There is no dependence between the first and second pairs of criteria since the first pair relates to team features but the second pair relates to the individual features. Thus it is enough to show the absence of any dependence between the marks distribution for initial (primary) and end of course (last) tests and the participants' satisfaction level. Methods of range correlation between the quality parameters were used for this proof. The Kendall correlation factor [3, 4] was found $\tau = 0.265$ which is as relatively small one. Testing of the correlation factor has shown that the hypothesis about the dependence between given criteria with probability 0.99 shall be rejected.

PERSONNEL TRAINING EFFICIENCY

System suggested of the training efficiency criteria is the basis of independent assessments. However there are four parameters to assess the training efficiency. It is expedient and possible to describe the overall training efficiency using just one numerical figure. This numerical figure is termed the generalized mark of efficiency. In order to find out the generalized mark of efficiency we define certain weighting parameters w_i for each of efficiency criteria so that the sum of weighting parameters is equal to unit $w_1+w_2+w_3+w_4=1$. If all four criteria would be equivalent, weighting parameters w_i would be equal to 0.25, however not all criteria are equivalent. We took the weight $w_1 = 0.3$ for the first criterion, the weight $w_2 = 0.2$ for the second criterion, the weight $w_3 = 0.3$ for the third criterion and the weight $w_4 = 0.2$ for the fourth criterion.

Criteria described are variable within different ranges. The first criterion holds its values from 0 to 2, the second from 0 to 0.6, the third from -2 to 2 and the forth from 3 to 5. Taking into account these ranges the following equation is given to assess the overall training efficiency:

$$E = w_1 \frac{\Delta_{mean}}{\Delta_{\max}} + w_2 \frac{\sigma^{in} - \sigma^{end}}{\sigma^{\max}} + w_3 \frac{\Delta_b}{\Delta_{b\max}} + w_4 \frac{b_{mean}^{sat} - b_{\min}^{sat}}{b_{\max}^{sat} - b_{\min}^{sat}} \qquad \text{(Eq. 1)}$$

where index "max" or "min" indicates the maximum or minimum of values. The value of E is the generalized mark of the training efficiency. As a threshold criterion of efficiency can be considered E=0.5. If the value of E obtained via Eq. 1 is smaller than 0.5 the training can be considered as not enough efficient, if E exceeds 0.5 the training is considered to be efficient. For example IETC training courses held in 2004 were characterized by $\Delta_{max}=2$; $\sigma^{in} = 0.827$, $\sigma^{end} = 0.332$, $\Delta_b = 0.73$, $\Delta_{bmax} = 2$, $b_{mean}^{sat} = 4.07$, $b_{\min}^{sat} = 3$, $b_{\max}^{sat} = 5$, which resulted accordingly to Eq. 1 in E = 0.53. This assessment shows that these training courses were efficient.

CONCLUSION

A system of quantitative parameters for the assessment of the training efficiency was developed. The overall training efficiency termed the generalized index of the training efficiency can be estimated by a numerical parameter. Methodology developed can be used to assess training efficiency for the personnel working in the area of radioactive waste management as well in other areas.

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