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Theory and Application of the Operation Learning

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Scope of Study: Several decades have passed since a learning curve was taken into consideration in the field of Industrial Engineering. A learning curve was first proposed in the air-craft industry in 1925. However, it was not until World War II that this theory was used on a large scale in America. The theory of the learning curve was first applied for predicting production times, estimating costs, forcasting requirements, and bidding new work. Theoretical research of the learning curve has been continued since that time and, as the result of the research, mathematical models which could express learning phenomena were developed. Especially a log-linear model was the one which was practically useful. The concept of learning has been developed also into largish concept with many mathematical models involved; that is, an improvement curve, manufacturing progress function were introduced and they were used for checking work progress in the system. They were also used as a management index for production planning. A learning effect was observed in the motion study and educational or training program for work was designed under the consideration of the learning effect. Cost estimation concerning products which were made in a subcontact factory was carried out in accordance with the theory of the manufacturing progress function. These activities were called dynamic evaluation. Learning phenomena were investigated and the theory of the learning was used in various ways in industry. However, learning phenomena were treated as a matter of secondary importance in industry, for they were used mainly for compensation of the standard time, they were used only for information of bidding or reorder products.

This dissertation has been undertaken as an attempt to develop the theory and uses of the learning curve which is a single technique into Learning Engineering under the name of Operation Learning. The theory and applications of the Learning Engineering have been developed and integrated into one document.

Findings and Conclusions: The learning curve, a single technique, has been elevated to a higher level of engineering called a learning engineering and the theory and applications of the learning engineering have been integrated into one document. Fundamental theory of the learning engineering was established and the theory was proved experimentally and practically right in various industries. Many applied theories were developed and introduced to industry and brought into effect. This study concludes that the learning engineering will be used extensively in various industries and dynamic evaluation concerning industrial activities will be made by this engineering method.

The following specific conclusions are inherent in the use of the learning engineering method:

1. New definition of the learning was established and it can explain the learning phenomena in a broad sense from the motion learning to the organization learning or productivity learning. Various learning phenomena were classified into several groups. Many mathematical models were developed and learning percentage, learning coefficient were defined precisely.
2. Learning phenomena have been divided into three categories: first term learning, middle term learning and final term learning. This division gave a great benefit in understanding actual industrial learning. The concept of the learning standard was newly introduced and its significance was explained. Also included is a discussion of work standard and a relationship to the standard learning percentage.
3. Standard learning table was made and it consisted of resources coefficient, learning coefficient, reorder factor, lot coefficient, and interference factor.
4. Lot coefficient was discussed theoretically and developed from the learning point of view. The standard lot sizes for various operations which have own learning performance were also investigated from the skirt point of the learning curve.
5. Resultant learning percentage was discussed and the interference table of the resultant learning was made. New log-nonlinear incompressible model was developed and the significance of it was shown.
   An exponential function type learning table was made and the mathematical model was presented. New mixed learning model was developed which could use for various operations, especially, for line production.
6. Relationship between the standard learning and the standard time determined by the Work Factor and Methods Time Measurement was studied and applied theory was developed. For instance, cycle coefficient which corresponds to its cycle number was introduced and the cycle coefficient table was made. micro motion learning was observed in many operations.
7. Learning curved surface was introduced and learning phenomena were grasped more precisely. This concept of the surface was applied to the field of machinary shop in order to estimate the time required for cutting. Experience learning was developed. It was used for predicting the time schedule in machinary shop. Learning surplus was studied and learning surplus coefficient table was presented.
8. Predetermined Learning Standard (PLS) method was created and various methods for learning performance determination were classified into five

categories. Each method was explained with advantages and disadvantages commented. The theory of the PLS was introduced and experimentally at the same time practically proved in several works.

9. Productivity learning was introduced and developed so that characteristic of the productivity has been explained dynamically. Many problems will be understood systematically from the view point of productivity learning. Productivity learning of various industries was investigated. Each industry which has own specific productivity learning can diagnose itself compared with its competitive company. Even in a company, if it was consisted of several factories and each factory productivity learning was measured, the factory can diagnose itself dynamically comparing with other factories. It can also select the best technique from among many techniques for automation, mechanization, motion betterment, work simplification, and so on without the partial optimum from the view point of productivity learning.
10. Clerical learning standard was investigated and indirect workers learning performance was measured. It was proved as a good tool for standardization of such a work and this learning standard was used for the estimation of automobile sales. Sales activities learning was also measured.
11. Critical Path Method was studied under the consideration of the learning effect. PERT was also treated from the view point of the learning effect. The analytical development of the critical path method under the influence of a learning effect is given and a simple example is presented. A critical path is usually fixed, namely it can never be changed without consuming some resources. However, the learning effect is considered here as one of the resources which can accelerate the activities which compose the network of a project.
12. Production scheduling was studied under a learnning effect and economic lot-size determination was carried out by the applied theory of learning engineering. Learning hysteresis coefficient was defined and developed. Residual learning was discussed as an intermittent learning phenomenon.
13. New concept of a quality learning was developed and this quality learning is available for dynamic quality control. Logarithmic control chart was introduced. Control curves are theoretically discussed and this quality learning is adopted in actual control of products.
14. Line-balancing problem was discussed under the consideration of the learning effect. The method of a learning limit coefficient determination was introduced. Learning models nature at first term was investigated from the view point of data transformation.
15. Various new models were developed. They were Concave type, Convex type,

K & k type, and Inverse-limit model. Elastic learning and Plastic learning were discussed theoreticaly. All learning phenomena were classified into fifteen types.

It can be concluded that an introduction of the learning engineering method into every industry is possible and will get fruitful results doing dynamic evaluation at any level of problems.