XVII IMEKO World Congress
Metrology in the 3rd Millennium
June 22–27, 2003, Dubrovnik, Croatia

THE LIFE-LONG EDUCATION FOR THE MEASUREMENT PROCESS IMPROVEMENT

Mladen Jakovčić[1] *and Armin Pavić*[2]

PLIVA Zagreb[1], Croatia
Faculty of Electrical Engineering and Computing The University of Zagreb[2]

Abstract – Human error has always been important component of the error of measurement. The use of modern technology, for capturing, transmitting, processing, manipulating and recording of measurement data, has eliminated human errors from the technical part of the measurement process, so that the main causes of human errors remain in the user area. A little space has been left for improving this aspect of measurement by technical means, therefore education has become an important tool for minimization of human errors. A systematic approach to user education is presented, with a pattern of continuous education similar to the measuring system life-cycle.

Keywords: education, measurement process, error.

1. INTRODUCTION

In modern society, characterized by the dominance of natural sciences, technology and global trade, measurement plays an important role. New knowledge in natural sciences is gained on the basis of measured values, all goods changing owners have to be measured, and quality assurance in industrial production is impossible without measurement. Even governments, to protect the population, are committed to assuring reliability of measured parameters (safety at work, environmental protection, etc.).

Thus, various measurement processes have become a part of our everyday lives, and as

we are facing a continuing demand for improvement of measurement processes.

The measurement process consists of three principal elements – object of measurement, measuring system and user.

The object of measurement is the parameter, which has to be determined quantitatively. The main prerequisite for this is that the measured parameter is measurable, and this will not be further discussed in this paper.

The measuring system must assure that the measurement results are gained with an established and acceptable measurement uncertainty, and then process, store, present and send the measurement results in accordance with the previously defined user requirements.

The user of measurement result is at the final point of the measurement process and his task is to correctly interpret and use the measurement results. The performance of user's task depends primarily on his competence. The user competence comprises his knowledge, and sometimes also his skills.

The major possibilities for improvement of the measurement process performance lay in the area of the measuring system and user. The quality of the measuring system is continuously improving by the following technical activities:

- New measurement principles and methods;
- Improvement of accuracy and reliability of measurement of physical parameters;
- Standardization of measurement and measuring equipment;
- Transfer, storage and analysis of measured and calculated results;
- Presentation of measured and calculated results.

The performance of user's activities can be improved only by education. This aspect of the measurement process improvement is the subject of this paper.

2. EDUCATION TO ASSURE THE QUALITY OF USER PERFORMANCE

It is a global requirement that a person participating in the working process must have the necessary applicable theoretical and practical knowledge and experience, and be acquainted with basic development trends of the profession as well. In the international standard [1] it is stated that person performing tasks, which have an influence on the product quality, must possess proven competence, for which education must be assured and its efficacy verified.

Similar statements are presented in other relevant standards such as [2], which states that person participating in the measurement process must possess appropriate knowledge and skill. The acquaintance with legal regulations, which are set forth by the authorities in the field of legal metrology and other relevant legal requirements, should also be stressed.

In order to assure and improve the performance of user activities, the level and extent of knowledge required for each task should be determined.

After selecting personnel as competent as possible, the knowledge they already possess should be weighed against the required knowledge by means of the initial knowledge evaluation (dashed rectangle in Fig 1). Based upon the results of that evaluation, the required new knowledge can be identified as presented in Fig 1.

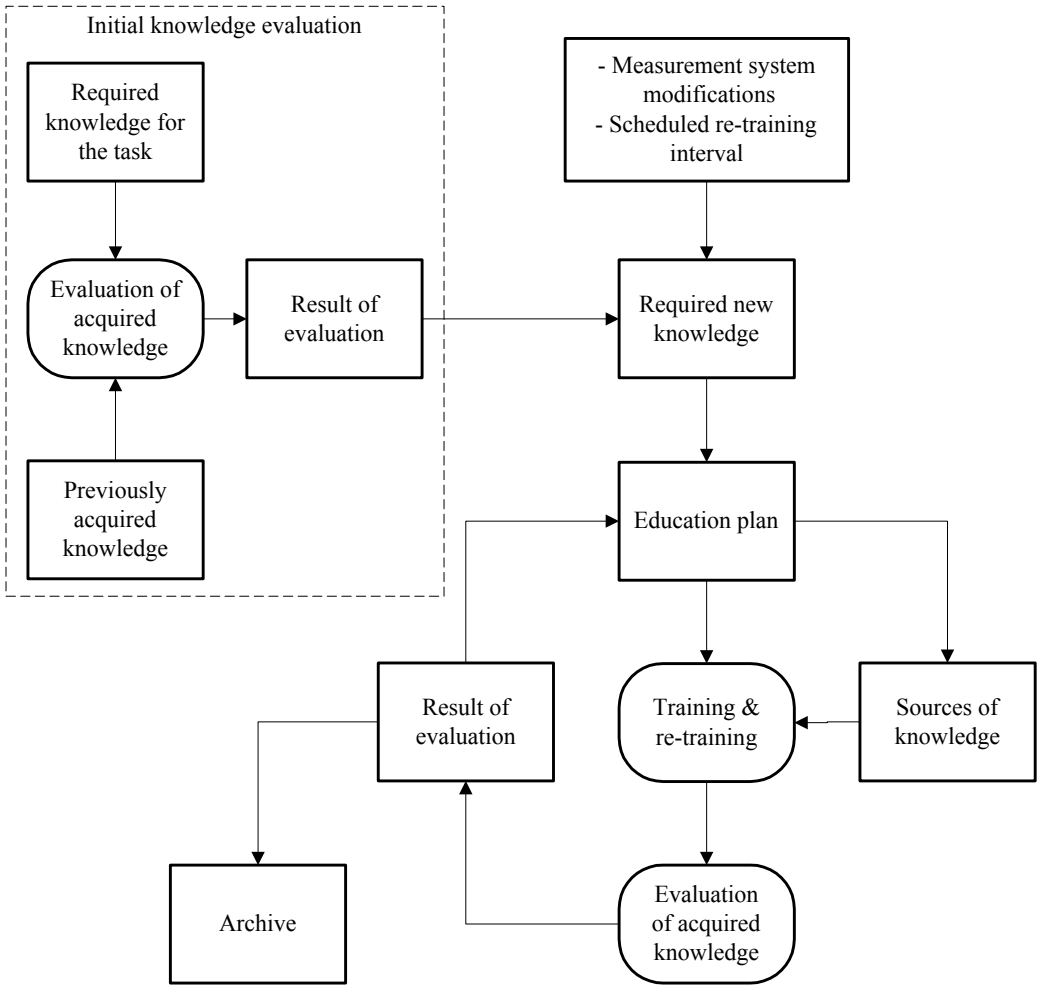

Figure 1. Flow-chart of the life-long education process

After the requirements for new knowledge have been defined, education plan is made, the adequate sources of knowledge are determined, and the necessary training is implemented. When the training has been completed, evaluation of knowledge is performed in order to assure that the person has gained competence to perform the specific task.

The components of the education process flow-chart, presented in Fig. 1, will be described in more detail.

2.1. Defining Knowledge Required For A Specific Task

Knowledge that is required for a specific task could be defined as system knowledge, or professional knowledge.

System knowledge applies to acquaintance with the quality system (company-dependent) and includes acquaintance with the company's quality manual as well as related procedures and operating instructions. It may also include other required company-related knowledge: organization, planning systems, methods for problem solving and other.

The main types of professional knowledge may be characterized as general knowledge (which comprises general technical knowledge and general measurement knowledge); and specific knowledge (which is related to a specific measuring system that is used by the user, focusing on the measurement equipment and process).

In the definition of the knowledge required for specific tasks, the general education programs (rules) of the company, international and local standards and recommendations, legal acts as well as recommendations of the manufacturer of the measuring system should be used.

2.2. Education Plan

After additional knowledge required by specified user has been defined, the education plan is prepared. Education plan must identify the adequate sources of knowledge and the way in which they will be used in the training.

Another important segment to be included in the education plan is the evaluation of knowledge acquired through the training, and the results of evaluation of

knowledge will confirm whether the education plan was appropriate or if there is a need for its modification.

Sources of knowledge are educational resources used for acquisition of knowledge by users. Typical sources of knowledge are courses, on-job-training (OJT), simulators, interactive training (using CD-ROM or Internet), self-learning, etc. Sources of knowledge must be combined and coordinated, as this is the only way to obtain long-term optimal results in education.

Evaluation of knowledge is necessary to confirm that competence has been achieved, since education itself does not guarantee that the knowledge has been acquired.

The objective of the evaluation of knowledge is (similar to testing of equipment) to detect possible gaps in knowledge before they cause problems in practice.

Most quality assurance standards require that the personnel must possess proven knowledge required for accomplishment of their tasks. In some instances the knowledge evaluation has to be conducted by authorized institutions (e.g., in the field of legal metrology).

Appropriate records should be kept on all evaluations of knowledge of users, and the results must be used as a basis for planning of further education.

2.3. Training And Re-training

The described cycle of additional education of a new user does not complete the user's education process. As with maintenance of equipment where periodic check-ups are required after modifications of the system, or after a certain period of use, users additional education should also be performed after any modifications of the system and after certain periods of time. That kind of additional education can be described as re-training.

The reasons for re-training are following:

- Acquisition of knowledge, the lack of which was noticed during the performance of user work assignments (usually by the inspection or audits);
- To refresh knowledge which has already been acquired but, since infrequently used in everyday work, may be reduced to an insufficient level;
- To acquire new knowledge, which may be the result of changes directly related to the tasks as process technology, measurement equipment,
- changes of legislation, or changes of other relevant procedures (quality assurance, new standards, recommendations etc.);
- To acquire general new knowledge, which should be related not only to the current task, but also to the anticipated tasks, in accordance to [3].

The objectives of re-training are maintenance and improvement of the user knowledge.

It is very important to recognize that the objective of re-training is not only to eliminate mistakes but also to foresee and prevent possible mistakes during work caused by insufficient level of knowledge.

Problems encountered in practice caused by insufficient level of knowledge should be systematically analyzed and corrective actions taken.

The co-operation with manufacturers of measuring systems, experience of users of these or similar systems, as well as the services of expert metrology consulting may be of great help in planning of the re-training.

In the pattern of user knowledge maintenance during the user education process, described in this section, certain similarities with the pattern of the maintenance of the technical part of the measurement process could be perceived.

The perceived similarities suggest the idea that the approach to the maintenance of the technical part of the measurement process, comprising corrective and preventive maintenance, can be applied to the user knowledge maintenance, as well.

That idea could simplify the quality assurance of the entire measurement process by applying the universal logic to the both components of the measurement process – the measuring system and the user.

3. ANALOGY BETWEEN USER EDUCATION AND THE LIFE-CYCLE OF THE MEASURING SYSTEM

Although this may not appear so at first glance, there is a number of analogies between the measuring system and the user, that could be established.

These analogies can be visualized by parallels between the life-cycle stages of the measuring system and the previously described stages of the user education process, that are presented in Table 1.

TABLE I. Parallelism between the phases of the measuring system life-cycle and the user education

Measuring system	User
Requirements specification	Required knowledge specification
Project (Design qualification)	Education plan
Implementation	Training
Validation	Knowledge evaluation
Maintenance and calibration	Re-training

As the final two stages in the life of the measuring system are constantly repeating, making a system life-cycle, in a similar manner the final stages of user education are repeating making the user education a continuous process which we may call life-long education.

The presented possibility to establish the similar formalism in treating both components of the measurement process - the user and the measuring system – could be of special importance for the systematical approach to the measurement process quality assurance.

3. CONCLUSION

In the measurement process, constant technological changes, which are primarily the modifications of the measuring system, are reflecting on the relations between the measuring system and the user.

The user can follow constant improvement of the quality of measuring system only by permanent education in the manner described as a life-long education, which could be considered analogous to the continuous maintenance of the measuring system.

The establishment of the same logic of activity in improvement of both parts of the measurement process facilitates the quality assurance of the entire process.

The primary objective of the maintenance of the measuring system is to improve the system availability, by means of the preventive approach. This should be applied to the user education as well.

The principle of life-long education allows a constant improvement of user knowledge, so that human errors can be effectively eliminated from the measurement process.

REFERENCES

[1] Standard ISO 9001, Quality management system – Requirements, ISO, 2000.
[2] Standard ISO 10012-1, Quality assurance requirements for measuring equipment – Metrological confirmation system for measuring equipment, ISO, 1992.
[3] Standard ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories, ISO, 1999.

Authors: Mr. sc. Mladen Jakovčić, PLIVA Održavanje, Prilaz baruna Filipovića 25, HR-10000 Zagreb, Croatia, Phone: +385 1 3781 083, E-mail: mladen.jakovcic@pliva.hr
Prof. dr. sc. Armin Pavić, OEEM Dept., Faculty of Electrical Engineering and Computing the University of Zagreb, Unska 3, HR-10000 Zagreb, Croatia, Phone: +385 1 6129 777, E-mail: armin.pavic@fer.hr