MUVOT - ESTABLISHING AN INTERNATIONAL VOCATIONAL TRAINING PROGRAM ON THE TOPIC OF MEASUREMENT UNCERTAINTY

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Abstract:

Measurement results represent important information, which are necessary for evaluating and improving the quality of manufactured products and to control manufacturing processes. Furthermore, they build the basis for numerous decisions in the field of quality management, process and production automation or product development and design.

Knowledge about the acquisition, evaluation and interpretation of measurement data as well as an understanding of the relevant influences on those measurement results are essential for employees working in the field of manufacturing metrology. Measurement results are always afflicted with deviations, due to a variety of causes. It follows that in order to assign a value to the reliability and quality of a measurement result its uncertainty must be determined and considered. However, employees in the field of quality management or metrology are often not familiar with methods for determination and interpretation of measurement uncertainty, because appropriate opportunities for training are missing in current vocational education.

This need has led to the creation of the European project MUVoT, which will create a course for advanced vocational training in determining measurement uncertainty. The training course is based on a blended learning concept, combining self-dependent learning via a web-based platform and face-to-face workshops. This allows the adaption of individual knowledge and skills by self-controlled learning of abstract contents whilst the exercises enable the practical application of typical methods, which are generally considered as quite complex by many employees, and thus assure correct understanding. The featured Blended Learning concept facilitates the integration of the training into a workplace setting, thus the idea of Lifelong Learning is promoted in new fields of application. The curriculum and training concept for this newly developed training program have been designed such that the course can be applied internationally. To facilitate this, a harmonized scheme for course structure and contents has been defined albeit with inherent flexibility, allowing the adaptation to specific constraints.

Keywords: Measurement uncertainty, Advanced vocational training, International harmonization

1. INTRODUCTION

One of the key requirements of quality management according to ISO 9001 is the sustainable improvement of the employees' skills and knowledge. An adequate qualification of employees for their respective tasks is a basic requirement to ensure the quality of any product. Especially in metrology, an operator's lack of knowledge may cause erroneous or unreliable measurement results. The complete declaration of any measurement result has to contain its measurement uncertainty, which is defined as "non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurement, based on the information used" [1]. To determine this uncertainty, all influences affecting the measurement result must be taken into consideration. Although the GUM – "Guide to the expression of measurement uncertainty" [2] - and other standards based upon it [3] provide a comprehensive guide comprising methods and procedures to determine the measurement uncertainty, most employees in manufacturing metrology are not familiar with this standard or even with the concept of measurement uncertainty, because it is not part of their education. To close this gap, enable the operators achieving the required knowledge and minimize the risk of unusable measurements caused by inadequate estimation of measurement uncertainty, a profound, well organized advanced vocational training is required. Therefore, MUVoT – "Blended Learning Course on Measurement Uncertainty for Advanced Vocational Training" (Leonardo da Vinci – Transfer of Innovation 2011-1-PL1-LEO05-19870) – has been developed.

In 2009 to 2010, in the international project "SAM-EMU - Statistical Analysis of Measurement Data for the Evaluation of Measurement Uncertainty", an eLearning-based educational offer on this topic was created, focusing on students at universities [4]. There, a comprehensive curriculum for the area of measurement uncertainty has been developed. The course provided in SAM-EMU enabled a European harmonized approach on qualification for measurement uncertainty and allowed for the inclusion of this subject in vocational education of engineers on university level.

Yet, the needs of learners in industry differ from those of university students in many aspects. Thus, to provide a training offer suitable for advanced vocational training for typical employees in manufacturing metrology, the project MUVoT - "Blended Learning course on Measurement

Uncertainty for Advanced Vocational Training" was initiated. Therein, a qualification program shall be developed, which focuses on the specific requirements of industrial employees in manufacturing metrology.

2. PARTNERSHIP

For training offers in manufacturing metrology, an internationally harmonized approach is preferable, fitting the often international exchange of measurement results along the supply-chain. Thus, the project was initiated as a European-wide cooperation, the consortium involving seven project partners from six different countries as listed in the table below.

Table 1: Partners of the MUVoT project

Partner institution	Country
University of Bielsko-Biala, Laboratory of Metrology	Poland
Friedrich-Alexander-University Erlangen-Nuremberg, Institute of Manufacturing Metrology	Germany
University of Huddersfield, Centre for Precision Technologies	Great Britain
University of Padova, Department of Innovation in Mechanics and Management	Italy
Technical University of Cluj-Napoca	Romania
Interstaatliche Hochschule für Technik Buchs NTB	Switzerland
International Foundation for World Class Manufacturing	Poland

3. PROCEDURE OF DEVELOPING MUVOT

To ensure an efficient and targeted development of the MUVoT course, a methodical approach concerning eight phases is used. Pertaining to the first and second step, “analysis of needs and competences” and “definition of the learning objectives” (Fig.1) results and findings from the afore mentioned previous project SAM-EMU can be used. However, establishing a target group oriented design, new specific needs and previous knowledge of potential participants must be identified. Thus, the third step represents the interface between the projects, because results and ideas from SAM-EMU can be considered as input quantities for MUVoT, thus the further development started at this point.

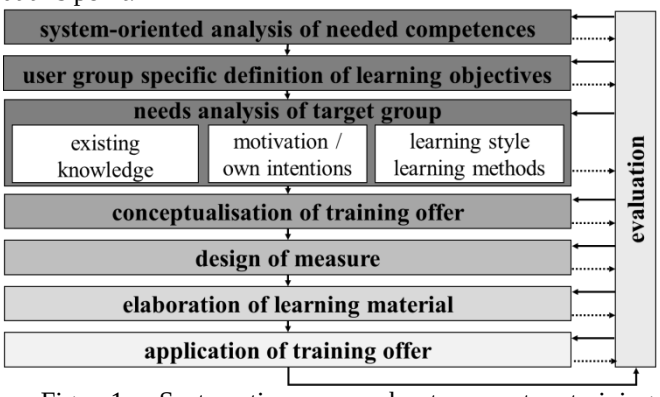

Fig. 1: Systematic approach to create training opportunities [5]

Based on results from a comprehensive requirements analysis, a specified learning provision can be conceived by choosing an adequate implementation modality. According to the stipulated arrangements, teaching and learning materials can be elaborated and used for the execution of the vocational training. Both accompanying the creation as well as the last step of the methodology, an evaluation has to be performed to identify existing need for improvement. The structured approach as well as the documentation of the results of conducted steps enable targeted improvements.

4. ANALYSIS OF REQUIREMENTS OF THE NEW TARGET GROUP

Analyzing the needs and requirements of the target group, prior knowledge, motivation for participation and typical learning behaviour must be considered to provide a useful learning provision. These factors influence the selection, weighing and structuring of the content by setting the base level, the overall concept of the course, which should correspond to the respective motivation, and the resulting constraints and opportunities regarding the didactic structure of knowledge transfer. By changing the target group, adaption of existing concept and material is required, as shown in the following table 2. Differences in the typical educational background of the target group are particularly evident in general, non-subject-specific skills, such as knowledge of mathematical methods and languages [6].
In both groups, the knowledge needed for statistical basics is very inhomogeneous. However, employees in industry are mostly not familiar with statistics, because it is not part of their education and daily work. Therefore, learning materials for refreshing basic knowledge must be provided.

Table 2: Comparison of the requirements for the courses "SAM-EMU" and "MUVoT" and resulting adaptation needs

Requirement in SAM-EMU	**Requirement in MUVoT**
Target group: Students	Target group: Employees
Inhomogeneous mathematical knowledge, typically sufficient	Inhomogeneous mathematical knowledge, typically not sufficient
Acquired knowledge will be used later (after graduation)	Acquired knowledge is used immediately
Abstract imparting of knowledge possible	More practical terms required
Acquisition of knowledge as the main task	Acquisition of knowledge as additional task
International, taking into account the language skills	International, taking into account the language skills

Resulting tasks for the course MUVoT
Imparting of mathematical basic knowledge
Varied exercises and examples
Supplement of course content by topics with high practical relevance
Course in national language

In general, the new target group is not as familiar with English as students. Therefore, course materials have to be translated to the national languages. Providing the same content in five different languages, an international harmonized vocational training course can be offered, enables the comparability of skills even in international business relationships and guarantees a uniform European qualification offer. This contributes to a smooth transfer of information and thus an improved product and process quality. Regarding the motivation of the participant, practical terms are more important for the new target group. Although many employees are not familiar with computer applications, the analysis of user requirements showed strong disposition towards new didactical methods such as eLearning [4]. All these aspects presented need to be taken into consideration, providing a useful vocational training.

5. CONCEPT OF EDUCATION

After analyzing the requirements, a suitable concept for the design of the training has to be defined. This includes the definition of the curriculum with the content to be taught, determining the appropriate form of training and planning of the course schedule, taking into consideration the integration of the training into a workplace setting.

Designing the curriculum, content can be adopted by the existing and proven course SAM-EMU [4]. However, adjustments of the required higher practical relevance and the slightly lower skills are needed.

Seven modules (2-8) form the basis for the course and additionally, two optional modules act as supplement. On the one hand, the first module provides some basic knowledge about statistics and on the other hand, the last module contains additional information about “Uncertainty in case of multivariate measurands”. Modules 6 to 8 comprehend practical training with additional topics of special relevance in industry.

6. SPECIFYING THE TEACHING-LEARNING METHODOLOGY

In selecting an adequate teaching-learning methodology, it needs to be considered how the defined learning objectives in the curriculum can be achieved. For vocational training, profound theoretical knowledge plays an important role as well as a practical acquisition, to guarantee a sustainable learning success. Therefore a high level of flexibility and adaptation to individual interests and previous knowledge is required.

To combine the advantages of these two forms of learning, and to meet the existing, partially conflicting requirements, a blended learning approach is appropriate. The conveyance of course content is performed by self-directed learning with e-learning materials that are supplemented by workshops, where content will be demonstrated and applied in practice. Thereby, specific measurement tasks can be analyzed and the measurement uncertainty can be determined. For more complex applications special software is used. Thus, a bridge is created between the e-learning concept and the classic, familiar teaching.

Table 3: Content of MUVoT

Topic of the module		Category
1	Basic statistics – Basics of descriptive statistics and stochastic – Analysis of correlation and regression – Statistical estimation and testing	optional element
2	General methodology of uncertainty evaluation – Uncertainty budgeting according to GUM – Overview of approaches to uncertainty calculation – Documentation and interpretation of measurement uncertainty	core element
3	Uncertainty of conventional measurements – Introduction to conventional measurements and main error sources – Uncertainty budgets for typical examples of conventional measurements (gauge blocks, calliper, micrometre, dial gauges)	core element
4	Uncertainty of coordinate measurements – Introduction to Coordinate Metrology – Evaluation of uncertainty using calibrated workpieces – Evaluation of uncertainty using computer simulation	core element
5	Uncertainty in surface roughness measurement – Introduction to Surface Metrology – Evaluation of uncertainty using ANOVA method – Evaluation of uncertainty using computer simulation	core element
6	Uncertainty in calibration – Requirements of a Calibration Laboratory – Calibration monitoring	practical element
7	Measurement systems analysis (MSA) – Aim and Framework of Measurement Systems Analysis – Characterising properties of measurement systems	practical element
8	Economics in manufacturing metrology – Quantification of inspection process costs and value-adding – Economic evaluation of investments in metrology	practical element
9	Uncertainty in case of multivariate measurands – Introduction to advanced modelling of measurements – Uncertainty analysis with correlation calculation	optional element

7. DESIGN OF THE COURSE SCHEDULE

The course schedule is based on the alternation of e-learning phases and workshops. Depending on the participants, one or two workshops can be held. Finally, an exam is performed and, if passed, a certificate is awarded to verify the acquired competences (Fig.2). Before starting the first learning phase, an additional introductory workshop will be offered during which use of the e-learning platform is explained. To enable an efficient arrangement of the individual learning process, some information about self-organization of learning is provided. During the self-learning phase, qualified tutors coach the participants and provide support [6].

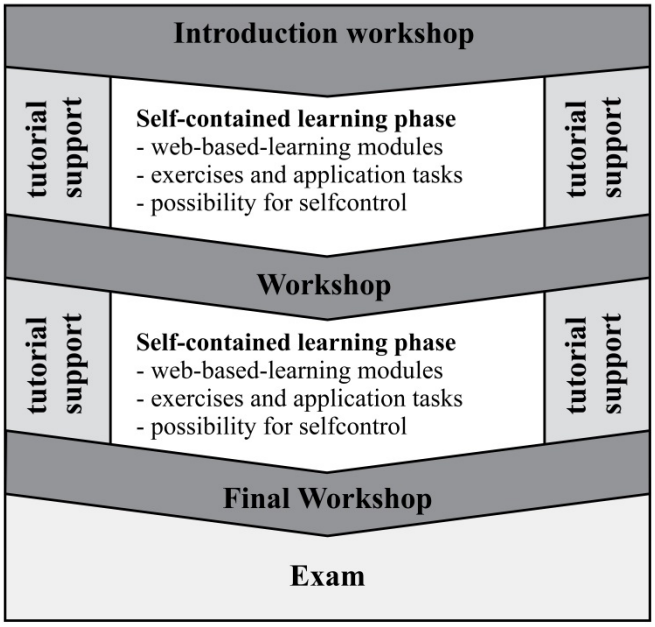

Fig. 2: Course Schedule of MUVoT

8. CREATION OF TRAINING MATERIALS

In creating training materials, existing materials have to be adapted to the new target group, concerning technical configuration and content. The considered requirements were collected in surveys from other existing courses. Regarding use of multimedia applications, one has to be careful and conservative, because in some companies, it could be a problem, concerning IT security, to install any software. For that reason, animations or interactive elements should not occur and sound effects may also be unfavorable, disturbing colleagues. In figure 3, the design of the provided course materials for the self-learning phase is demonstrated. The navigation bar on the left site provides an overview of the module's content and facilitates the orientation.

9. OUTLOOK

The provided knowledge will help to increase the sustainability of products and processes as well as to introduce targeted quality improvements. Through better understanding of measurement results and their associated uncertainty, resources can be used more efficiently and rejections by costumers will be reduced.

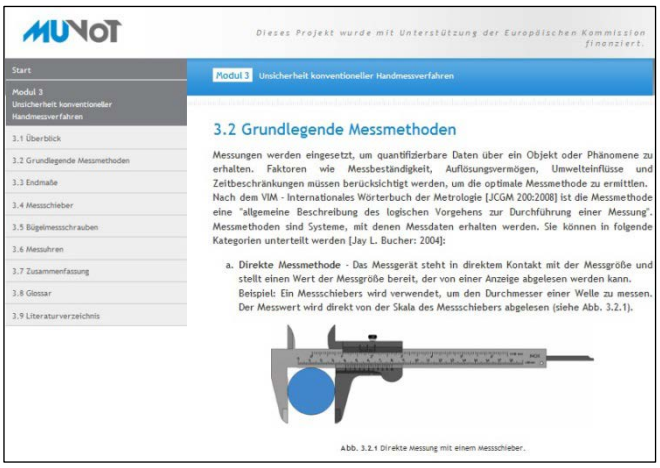

Fig. 3: Screenshot of MUVoT HTML

Thus, the qualification of employees in the subject of measurement uncertainty has the potential to have positive monetary effects whilst also increasing customer, consumer and producer satisfaction.

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