Computer-assisted generation of individual training concepts for advanced education in manufacturing metrology

Teresa Werner, Albert Weckenmann

Chair Quality Management and Manufacturing Metrology
Friedrich-Alexander-University Erlangen-Nuremberg
Naegelsbachstrasse 25, 91052 Erlangen, Germany
Tel.: +49 [9131] 85-26516 Fax: +49 [9131] 85-26524
E-mail: teresa.werner@qfm.uni-erlangen.de

Abstract
Due to increasing requirements on the accuracy and reproducibility of measurement results together with a rapid development of novel technologies for the execution of measurements, there is a high demand for adequate qualification of metrologists. Accordingly, a variety of training offers is provided by machine manufacturers, universities and other institutions. Yet, for an interested learner it is very difficult to define an optimal training schedule for his individual demands. Therefore, a computer-based assistance tool is developed to support a demand-responsive scheduling of training. Based on the difference between actual and intended competence profile and under consideration of amending requirements, an optimally customized qualification concept is derived. For this, available training offers are categorized according to different dimensions: Regarding contents of the course, but also intended target groups, focus of the imparted competences, implemented methods of learning and teaching, expected constraints for learning and necessary preknowledge. After completing a course, the achieved competences and the transferability of gathered knowledge are evaluated. Based on the results, recommendations for amending measures of learning are provided. Thus, a customized qualification for manufacturing metrology is facilitated, adapted to the specific needs and constraints of each individual learner.

Keywords: Advanced vocational training, computer assistance, manufacturing metrology

1. Introduction
Correct results of measurements during industrial quality control have a high impact on the success of the company, as precise and reliable information about the geometrical features of a manufactured component are an indispensable condition to deliver only high quality products meeting defined specifications. Due to this demand on increasing accuracy of measurement results together with narrowing constraints of acceptable inspection time, manufacturing metrology constitutes a rapidly developing field of technology. Therefore, employees regularly have to accomplish the application of new technologies in measurement devices, demanding not only the proper handling of the specific machine, but also a profound understanding of relevant influences in order avoid an unnoticed biasing of the measurement causing erroneous results.

Due to this need of consolidation and enlargement of competences regarding metrology, adequate arrangements of continuous qualification have to be provided to enable a process of Life Long Learning. This is of special importance as many employees working in this area do not have a sufficient basic education as metrologist. Yet, comparing different employees or different fields of application in manufacturing metrology, the intended profile of competences as well as the existing basic knowledge varies strongly. Thus, also the required qualification depends strongly on individual constraints.
Although a large variety of training offers is provided by the manufacturers of measuring machines, universities or other institutions, the specific demand of a learner will rarely be met by a ready-made training concept as this is adapted to the requirements of an abstract user group described by typical constraints and average abilities. Therefore, a combination of courses for an individual training concept is required. Yet, it is very difficult for the learner to identify adequate courses and define an optimal training concept – all the more so, if the learner has only small basic knowledge on the considered area, or the choice is not taken by himself but by a superior or a person from another department not in connection with the actual work to be executed, e.g. a staff member of human resource development.

Thus, to support the learner with the selection of appropriate training offers and enable the definition of an individual training concept based on the specific demand, an adequate facility for assistance is required.

2. Conceptualization of an assistance tool for scheduling of qualification

Regarding advanced vocational qualification, the never ending demand for continuous improvement usually is envisioned as a staff development cycle rather than as a unique event. To describe the phases of this development cycle, different models are used [e.g. 1, 2]. Yet, they can be summarized in a seven stepped model (Fig. 1): Analysis of required competences, Assessment of available competences, Identification of demand for qualification, Election of adept training offers, Participation in training, Utilization of gained knowledge in professional tasks and finally Assessment of training success. Based on the results of the assessment or driven by new requirements, the cycle will start all over again.

Regarding these phases, there is usually a strict focus on the actual participation in training, both in the development of adequate offers and in the providing of tools for quality assurance of training. Yet, the success of a measure of qualification, expressed by the resulting ability of the participant to perform his tasks correctly and efficiently, does not only depend on the training itself, but also on the preceding phases of planning and election of the training offer as well as on the subsequent transfer of newly gained knowledge and skills to the performance of actual tasks. Therefore, an appropriate assistance tool for the scheduling of qualification has to support the whole cycle of staff development.

As a basis for the further development, requirements for the tool have to be specified, regarding both functionalities and overall properties. Regarding properties, especially user friendliness has to be considered. The system has to be easy to handle, robust against possible user mistakes and self-explaining. The imparted information has to aim for completeness regarding trainings on the market and for correct descriptions. Also, preferably the tool shall be accessible by all interested employees in metrology in order to enable target-oriented advanced training. For this, independence of other systems and low requirements on a user’s computer are desirable. In order to define the intended functionalities of the tool, based on the seven stepped model for each phase it has to be analyzed, in which way a person trying to find suitable measures of qualification could be supported. This concept of functionalities can be summarized in a workflow diagram (Fig. 1).

During the first two steps, analyses of competences have to be executed, regarding on the one hand the competences required to fulfill the given tasks correctly and efficiently, on the other hand measuring the current competence profile of a specific person intended to perform this task. Here, it is necessary to provide a possibility for the comparable description of the intended or available competences. This has to include a comprehensive portfolio of relevant skills as well as an adequate set of categories for rating desired and current state against it. For both steps, the same scheme for assessment has to be used in order to provide a comparability between the two recorded profiles. This information also can be used as subject-specific input for job characteristics respectively performance appraisal of employees.
Fig. 1. Required functionalities of an assistance tool for holistic support during qualification cycle.

For the following identification of demand for qualification, targeted and actual competence profile have to be compared and occurring deficits have to be highlighted. Also, a recommendation is useful if additional training is necessary or if identified deficits are likely to be easily smoothed out by increasing experience in the execution of tasks or by exchange of knowledge among coworkers. In order to schedule measures of qualifications adequate for the specific situation of the intended learner, besides the content of training specified by the identified deviations of competence profiles also other constraints have to be considered. Thus, requirements regarding disposable time, acceptable costs, formal specifications such as level of education and previous training with accredited certificates, available technical infrastructure, preferred method of learning and other constraints, e.g. maximum travel time for seminars, have to be collected. Based on this comprehensive analysis of user requirements, possible training schedules can be first generated to cover the identified gaps in competences and then assessed regarding the fulfillment of the additional requirements. As a prerequisite for this recommendation, a data base of generally available training offers is required, where contents and circumstances are described. The results are displayed to the user, who selects one of the suggestions. If no suitable offers are to be found, the collected data may be used as specifications for an individually developed training.
For the actual participation in the qualification program, no support from the tool is required. Yet, afterwards of possibility for assessing the training should be offered. The gathered results can be included in the data base and thus enable a fine-tuning of recommendations. Also, suitable methods to support the transfer of newly gained competences to the performance of actual tasks and enhance activities of knowledge sharing with co-workers should be proposed to increase the effect of training for the actual participant as well as for the whole department [3]. Finally, after a certain time to assure an unbiased assessment the now available competences should be measured and compared with the target profile. Here again a standardized set of categories and observed skills is needed. Based on these results, the cycle eventually can be started all over again.

3. Design of essential features for the assistance tool

For the realization of the assistance tool, three essential features have to be developed: A method for competence analysis in manufacturing metrology, a strategy for the generation of possible training schedules and a multi-criteria analysis of the generated schedules.

A comprehensive competence analysis for manufacturing metrology has to consider in one dimension all relevant topics and in another dimension the various kinds of competences. Regarding topical categories, the field of manufacturing metrology can be structured in typical sub domains widely used for classifying the various inspection devices, e.g. gauges, coordinate metrology, form measurement etc. [4]. Additionally, basics of metrology have to be considered, such as interpretation of geometrical specification. For each topic, different modes of competences have to be assessed. In context of advanced vocational training, the focus is set on cognitive (“know that”) and functional (“know how”) competences as subdivisions of topical professional competences [5]. Other modes of competences, social and personal, may be neglected in this specific purpose, as their development – which is necessary for a high overall performance of the employee – can not be effectively provided via topical training but needs to be included in a more generalized learning culture in the company. For each topic, cognitive and functional competence are rated on an ordinal scale with five categories. Each category is described by the according typical level of performance to enable a transparent and reproducible assessment. The defined analytical items are also used to describe the learning aims of a specific course in the data base.

For the generation of training schedules two strategies are combined. Using “backward-strategy”, the target profile of competences is considered as starting point. Training offers that enable the achievement of the intended competences are selected from the data base. Their prerequisites regarding previous knowledge or formal qualification are compared with the actual profile. If the requirements are not fulfilled, the requested profile is considered as new target. The step is iterated until a schedule of successive courses is defined, connecting target and current profile. Using “forward-strategy”, the current profile is considered as starting point and possibilities to progress from here are checked. The possibility which provides the best reduction of gaps to the target profile is elected. If there is a remaining demand, the step is iterated. Generally, the backward-strategy is more likely to provide an effective training schedule, if there is a training offer imparting the required competences. Yet, the forward-strategy enables a preliminary break, e.g. if only a limited amount of costs are tolerated.

For the assessment of generated training concepts against the specified requirements, for each criterion (topical fit, costs, learning methodology, organizational constraints) a degree of fulfillment is calculated, expressed by a value between 0 and 100%. The relevant information for each course is also contained in the data base. The values of all criteria are combined by multiplication in order to avoid high ranking of schedules with severe drawbacks in one category. When displaying the rated training schedules, the ranking in each category is visible for the user. Thus, finally an informed decision can be taken for a specific training concept.
4. Evaluation of implementation strategies

Regarding the implementation of the actual assistance tool, there are two main possibilities: A realization as a closed system or as an open system. For a closed system, there would be a fixed set of possible users and also a limited choice of included training offers only to be changed or amended by especially authorized persons, bringing along the necessity of a regular update of the database in order to provide up-to-date information. But it would also be possible to include offers that are not commonly available, e.g. specific programs of an enterprise. Thus, an implementation as a closed system would be highly useful for the support of staff development in large companies. This can be realized by a classical software application with regular updates for each user or rather by a client-server application, which can be centrally updated. The latter would also enable a combination with existing similar systems in the company, e.g. for CAQ.

For an open system, the group of possible users is not limited. Rather, a facility to assess one’s competences regarding manufacturing metrology and schedule an appropriate training should be provided for all interested users. This would demand the implementation of a web-based platform. Including typical facilities of Web 2.0, the possibility to realize a community of practice should be used for the exchange of expert knowledge and experiences with a training offer could be taken into account by other users. Also, the need for completeness of the qualification offers included in the database could be met more easily, as providers could apply for an inclusion themselves rather than having to be found, even if the input in the database generally should be performed by qualified staff to assure comparability. Thus, the important aspects of social connectivity required for successful learning can be facilitated.

5. Conclusion and outlook

By a holistic assistance tool for the scheduling of advanced vocational training, an individually adapted generation of training concepts for manufacturing metrology is facilitated. Thus, measures of qualification can be efficiently oriented towards the specific demand of learner and company. So far, a functional concept as well as essential algorithms have been described. The feasibility of the concept has been checked and basic possibilities for the implementation have been analyzed. Currently, a prototype of an open system is developed including a facility for the assessment of competences in manufacturing metrology and an initial database of training offers. Thus, the general acceptance of the tool by the intended user group can be evaluated.

The developed concept for an assistance tool for the demand-oriented election of training offers is commonly applicable for advanced vocational training. Specification on a special topic is provided only via the training offers contained in database together with the assessment of competences for the field of metrology. Thus, the concept can be easily adapted also to other areas of interest.

References