Professional Improvement by Study in Engineering Sciences

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Abstract

The German industry is suffering from a lack of skilled academic workers. The Organization for Economic Cooperation and Development (OECD) performed a study, which predicted a further increase in the demand for engineers. In engineering sciences, the present number of graduates cannot support the number of engineers working in the industry at the current level. The issue is further aggravated by the fact that Germany has one of the lowest birth rates in the world. The average number of children in Germany is only 1.4 per woman in child bearing age. As a result, even in the long run the potential for maintaining a skilled engineering work force is bleak. However, maintaining the level of academically trained engineers is of utmost importance for the future industrial development of Germany. Since high school graduates will not satisfy the demand for engineering students, there is a substantial interest in finding alternative solutions. One is to address new groups who could become students in the technical area. A promising solution is to acquire engineering students out of the ranks of skilled workers and technicians by enabling a recognition of their vocational qualifications for their study. The Institute for Microtechnology (imt) at the Leibniz Universitaet Hannover has initiated the project Professional Improvement by Study (ProfIS) which is funded by the German Ministry for Education and Research (BMBF) to establish an easier access to engineering studies for skilled industrial workers. To evaluate the chances to recognize vocational competencies of skilled workers choosing an academic path, studies in high technology fields like Micro- and Nano-Technology (MNT) and Mechatronics were analyzed. The aim is to detect potentials to be recognized on particular skills and qualifications acquired by workers with advanced training in this specific fields.
For recognition, the previously achieved competencies of skilled and trained workers have to be evaluated and cross-linkages have to be installed with respect to the considered academic competencies. The chosen method to perform recognition of vocational competencies is as follows. First, the competencies of vocational training and work are evaluated based on the content, modularized, and reassigned to the achieved academic competencies. In the next step, the competencies are captured by learning outcomes and assigned in comparison level stages by the taxonomy of Moon. In the third and final step, the competences are evaluated and proven to allow for a fair and reproducible recognition. This procedure provides the ability to recognize vocational competencies in an individual way and even allows to using the results for blanket recognition for same or similar cases.
The approach chosen represented a flexible, clear, and coherent solution for acknowledging existing professional skills. The concept also lends itself for being transferred to other fields

where recognition of competencies from advanced trained workers is aspired. Thus, this approach provides a potential to satisfy the future demand for academic workers and opens new chances for vocational workers.

Keywords: ProfIS, professional qualifications, recognition of work experience, educational systems, high technology industries

Introduction

The actual OECD report “Education at a glance” indicates that in Germany the number of individuals holding an engineering degree in the younger age group does not match those who are leaving the labour market in the coming years. This ratio is currently below one, meaning that more people with engineering degrees are likely to leave the labour market due to retirement than the number of those entering the labour market in the near future with these degrees (OECD Publishing, 2007). Predictions on the future demand of engineers in Germany up to 2012 show that significant shortages in the supply of academics in general and engineers in particular will arise (Krebs, 2007). In the engineering fields like mechanical and electrical engineering including Micro and Nano Technologies (MNT) and Mechatronics, the highest demand for engineers is expected (Zukersteinova, 2007).

Since a high number of engineers is a backbone for the future development of Germany, it is necessary to target new groups of students in technical areas, which will augment students entering through the classic way (i.e. high school or high school equivalent degree, like the Abitur in Germany). Ways of tabbing into the reservoir of trained workers to fill the needs for academically trained personnel are one alternative.

For training workers on various skill levels, Germany has both an excellent apprenticeship system as well as a system for advance job training, e.g. for the education of master machinists or technicians. Each system allows to matching the personal abilities of an applicant within the employment interests of its country. Vocationally trained workers with a practical qualification and high technology skills represent a high potential candidate group. This is particularly the case since vocational field in Germany is strongly based on formal education and training and enables access to certificates of the formal competencies.

The project “Professional Improvement by Study” (ProfIS) funded by the Federal Ministry of Education and Research (BMBF) within the program ANKOM (Recognition of Professional Competencies at Universities) investigates the potential for attracting workers for academic studies. Therefore, the project aims at examining the acknowledgement of competencies acquired in vocational training and deepened by practical work en lieu of university courses. As a result, knowledge based on vocational and advanced training and specification in job is investigated for recognition on academic studies. By avoiding a double qualification of fields where a candidate already displays expert knowledge, the course spectrum for such a candidate will be reduced. This should not only motivate candidates to take this career path, but also allow them to move much faster through their university studies.

Fields particularly well suited to evaluate such innovative approaches are high technology areas like MNT and Mechatronics. The reason is that acquiring knowledge regarding fabrication technologies and metrology represent a major portion of the studies. Particularly in such fields, substantial overlaps between technology skills to be acquired through university courses and fabrication skills acquired through practical work do exist. This is

particularly true if a candidate went through a respective apprenticeship and continued to work in the same field. In such a case, a comparison of the apprenticeship curriculum and the actual work experience allows to pinpoint areas were credit points may be awarded. Particularly if the education program of the apprenticeship as well the course program of the university is modularized, such a comparison is rather simple. This way, the class requirements may be reduced of any fields teaching production and metrology knowledge.

Part 1: Initiation of the Project

The initiative of the Federal Ministry of Education and Research (BMBF)

As already mentioned, the Federal Ministry of Education and Research (BMBF) initiated the program ANKOM (Academic course credit for vocational competencies). This programme started in 2005 to investigate the description and detection of vocational and higher education competencies in terms of learning outcomes, the measurement of these competencies, and methods to evaluate potentials for recognition. The background of the program is the creation of a European Higher Education Area until 2010 based on the “Bologna Process” of the European Union and the Copenhagen Declaration with relevance to the Vocational Education and Training Area.
Within the scope of this program, there are 11 regional projects covering the fields of engineering sciences, information technologies, health and social care, and economic science. Engineering sciences are analyzed by the project ProfIS of the Institute for Microtechnology at the Leibniz Universitaet Hannover and by the project bkus-ing of the rectorate at the Technical University Ilmenau. The project ProfIS concentrates on curricula offered or initiated by mechanical engineering in the fields of Mechatronics and MNT. The main goal of the program is to improve the permeability between the vocational and advanced training and the academic education system. This way, it is expected that the motivation of skilled workers and technicians to attempt further education at universities will be increased.
Figure 1 presents the goals focused in this project.
All these goals are taken as steps to sustaining and enforcing the national economy for the competition on the global market. In order to carry out these goals, a prototype model was developed to evaluate the vocational qualification in respect to eligibility for substituting academic courses. This prototype model designed for one particular curriculum is intended to serve as a standard model for students from vocational fields. Therefore, it is expected to be transferable to other fields. The educational/political objective is to bring such models in agreement with livelong learning goals. As mentioned above, this approach shall also be in agreement with European goals of any educational system, as defined by the European Commission by the “Bologna Process”.

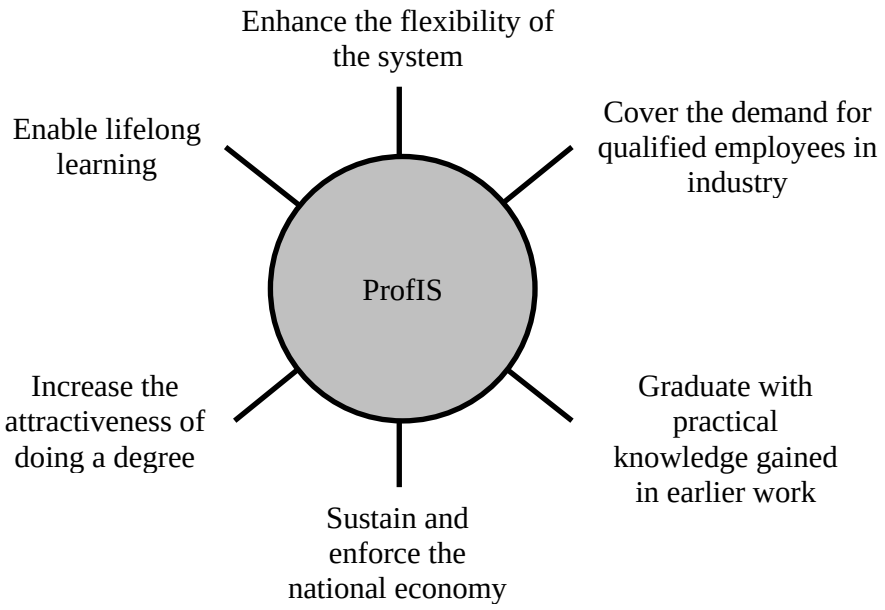

Figure 1: Intended goals of the project ProfIS

Part 2: Structure of the Recognition of Professional Qualifications

The Process of the Recognition of Professional Qualifications

To reliably facilitate recognition of professional qualification, a new concept has to be applied. Starting up with an inductive approach, the general procedure to develop a recognition program is to pick a specific case (which is for instance MNT) and then deploying the acquired experiences in the studied fields chosen onto other fields of mechanical engineering (Fig. 2). The next area viewed is Mechatronics, but there are also great similarities with as diverse subjects like Biomedical Engineering or Production Engineering. Each of the latter three fields represents course programs offered by the Leibniz Universitaet Hannover.

To analyze how formal professional qualifications may be acquired during the apprenticeship, the model developed by Erpenbeck and Heyse (Erpenbeck, Heyse, 1999) shall be used. It classifies three ways how advanced training and practical experiences in job may be acquired: formal, non-formal, and informal (Fig. 2).

Formal qualifications are obtained by certificates from various institutions. On the other hand, non-formal qualifications are gained during studies outside a formal system, for instance non-certified educational activities and duties. Informal competencies are acquired outside of the educational institutions, for example through training on the job. These qualifications are the integral parts of knowledge, which have to be considered for cognition. Figure 3 depicts the competencies of candidate students are based on the formal and informal qualifications of education, work experience, and work knowledge as discussed above. One approach to recognize the professional qualifications of an applicant is to analyze the learning packages he or she was subjected to during his or her vocational training (apprenticeship) and put them into perspective with the actual work experience gained in his field.

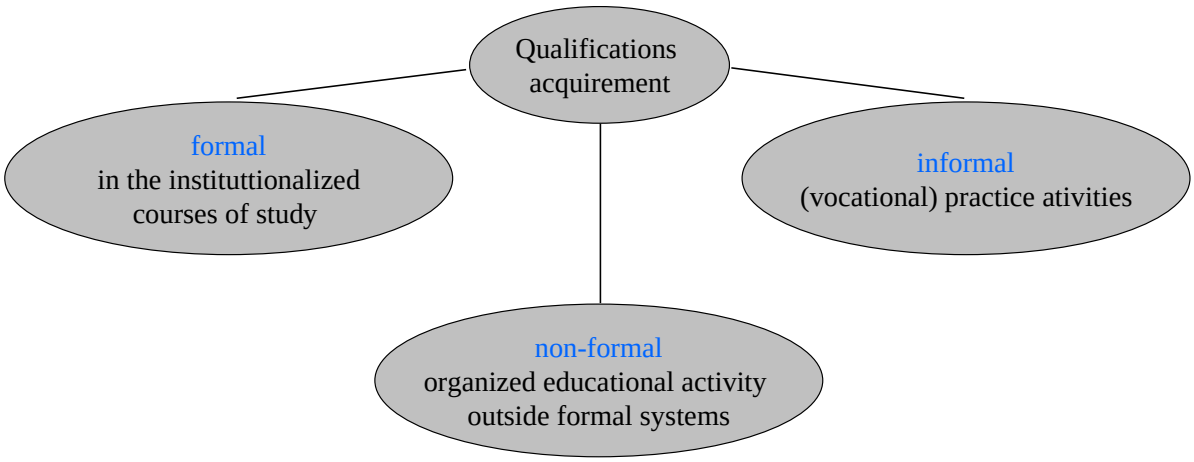

Figure 2: Acquirement of qualifications

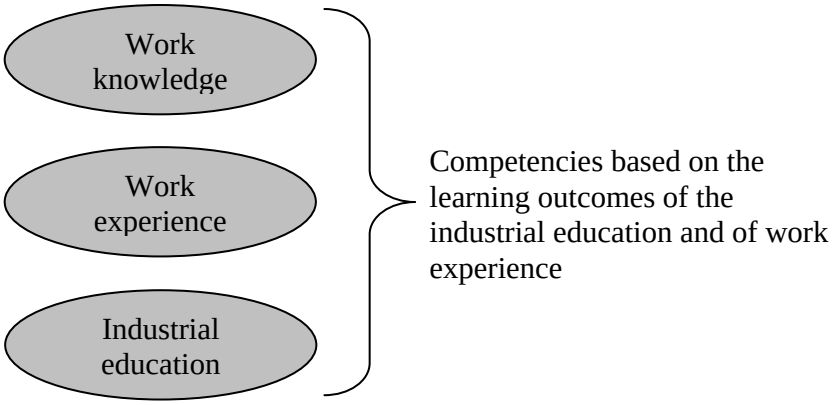

Figure 3: Stages of Competencies

Institutions of the German government in cooperation with industrial representatives regulate the vocational and advanced training. Learning packages are defined for the schools, educational institutions, and the companies for their vocational and advanced training. As input for a recognition process, the certificates of apprenticeship and work experience of an applicant are taken into account. The learning outcomes regarding to the learning contents then will be compared to the academic course program. The recognition process is presented in Fig. 4.

A study performed by Moon pinpoints the expected results of a learning outcome (Moon, 2004). (1) A verb that indicates what the learner is expected to be able to do at the end of the period of learning; (2) Words that indicate on what or with what the learner is acting; (3) Words that indicate the nature (in context or in terms of standard) of the performance required as evidence that the learning was achieved.

The academic learning outcomes and the learning outcomes in the vocational field are evaluated for credit approval. The academic learning outcomes are set as a standard for it. The method to detect the academic learning outcomes is described in Fig. 5. The description in the module handbook and the lecturer notes are evaluated and the specific interpretations of the lecturer have to be regarded.

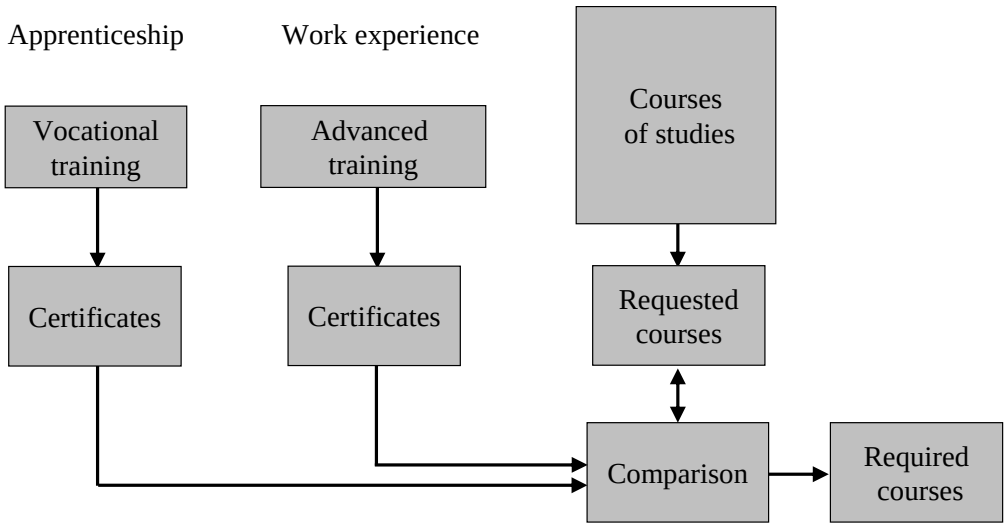

Figure 4: Recognition process

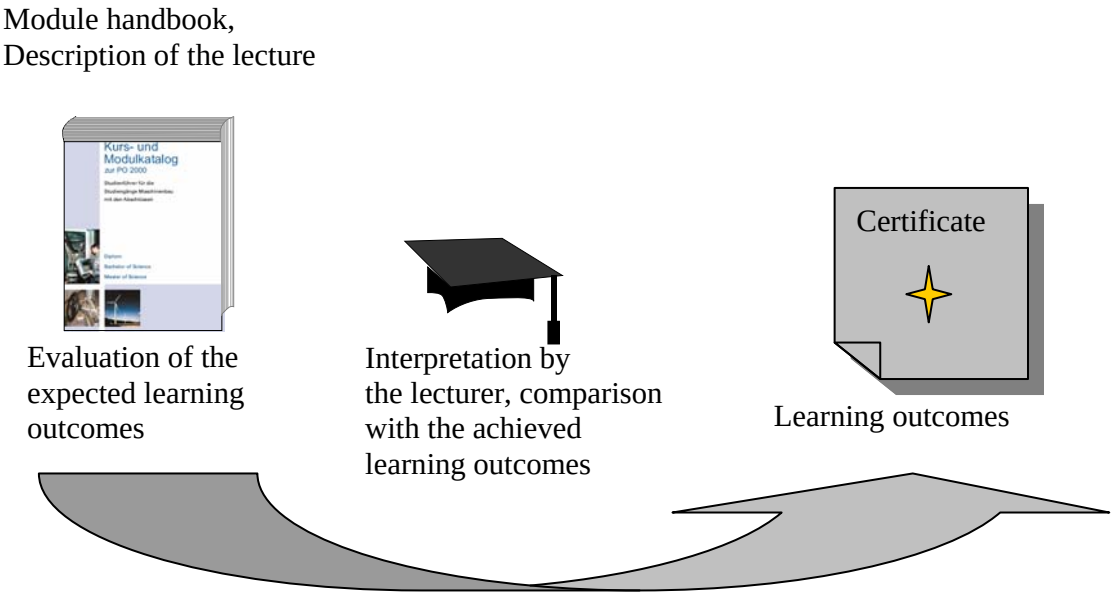

Figure 5: Detection of academic learning outcomes

Within the process of recognition, a decision has to be made to what extend the content of the competencies acquired by vocational training and advanced training are fitting the required competencies in the academic field. In many cases, the knowledge in the vocational field is not as deep, abstract, and theoretical as required for the academic field. To detect the equivalence of these competences, a diagnosis of the degree of equivalence of vocational and academic competencies is required (Fig. 7).

To define the level of the observed learning outcomes, the system of Moon (Moon, 2005) was chosen as diagnostic and evaluation tool. The approach of Moon is used in the United Kingdom to design programs and modules in studies as a context of level descriptors, learning outcomes, and assessment criteria. The approach was also adopted to the fiels of studies in Education, Arts, and Science according to Moon (Moon, 2004).

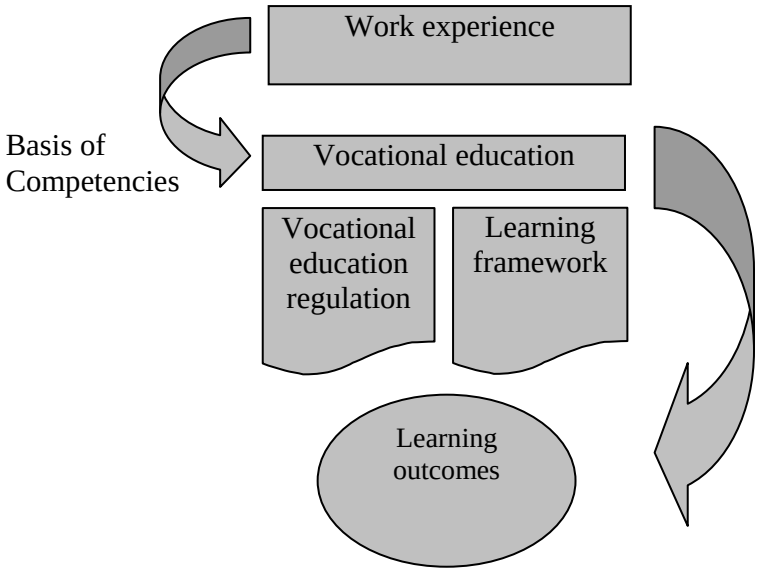

Figure 6: Detection of learning outcomes in the vocational field

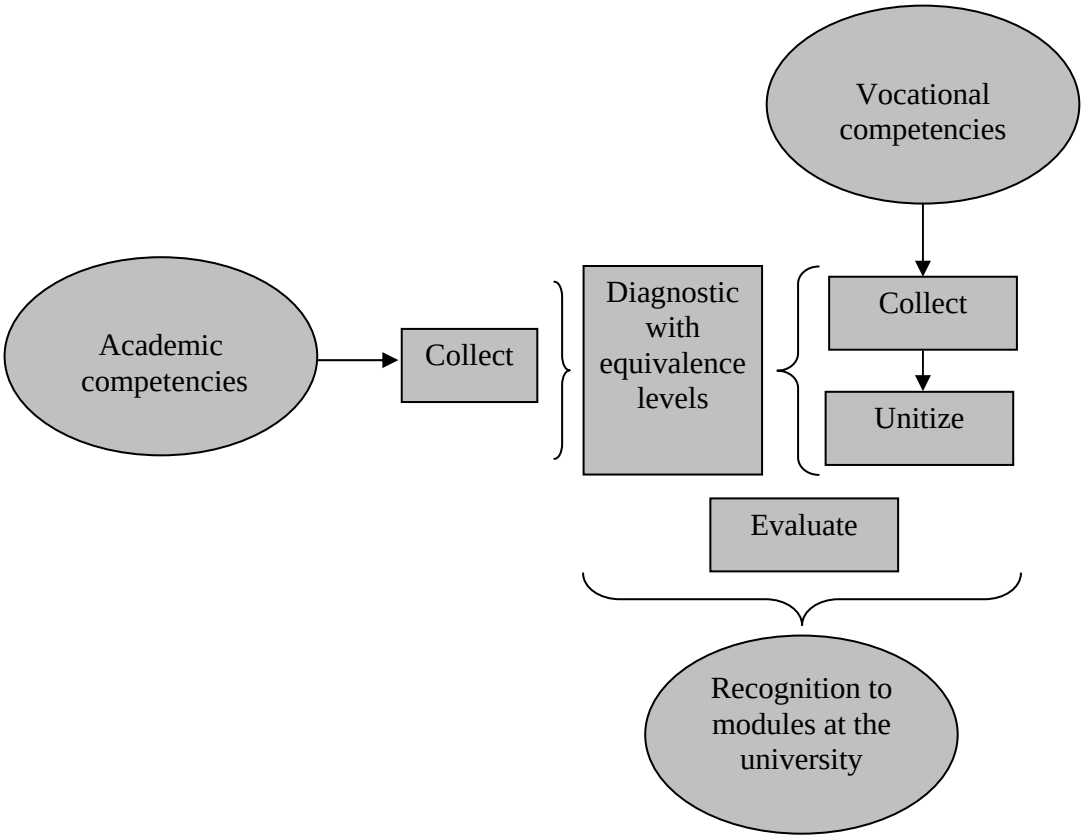

Figure 7: Conception for the data input to work with equivalence levels

In this system for assessments in higher education, the education achievement by learning outcomes is divided into six levels: (1) knowledge, (2) understanding, (3) knowledge/understanding, (4) analysis, (5) synthesis, and (6) evaluation. This concept is

based on the Taxonomy of Bloom (Krathwohl *et al.*, 1978), modified for the demands in many fields of higher education. Each level of competencies contains a description useful for categorizing the learning outcomes. The concept of relating the levels with learning outcomes is demonstrated in Fig. 8. The learning outcomes of an academic course (module 1) and of the created vocational "modules" are classified into levels and thus become comparable.

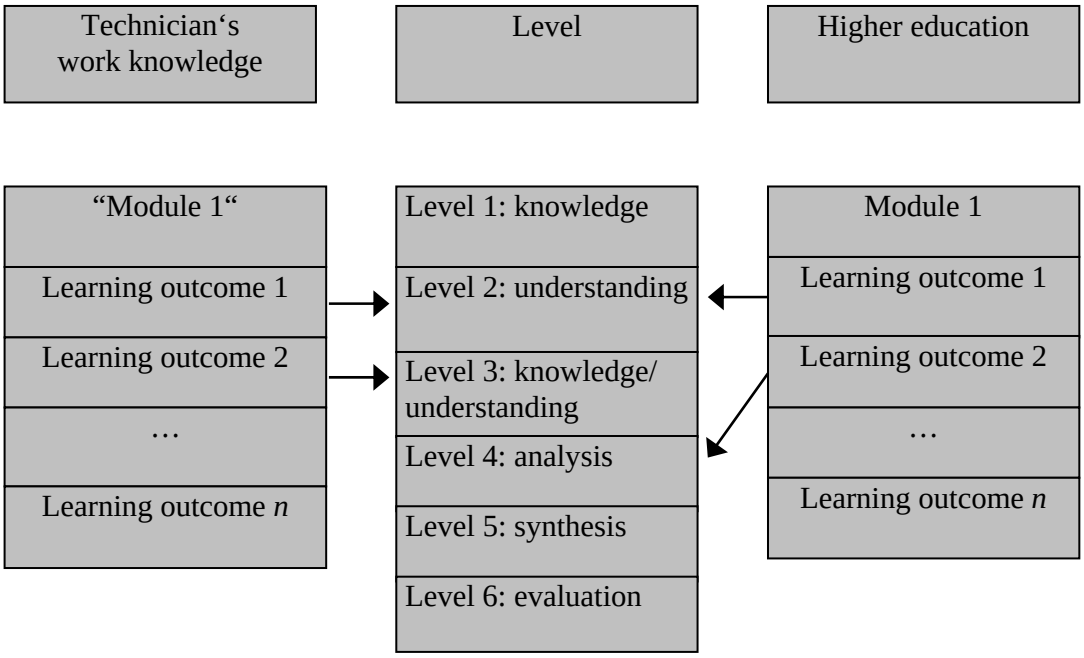

Figure 8: Concept for the recognition of equivalent competencies by standardized levels

If a substantial overlap of learning outcomes between the vocational and the corresponding academic "module" occur, a respective number of credit points will be granted en lieu of attending the academic course. Thus, the concept to credit equivalences by comparison of equivalence levels for learning outcomes is the basis for an overall recognition (Fig. 9).
Acknowledgement may either be pursued by Blanket Recognition (e.g. based on a combination of knowledge acquired through a combination of vocational and work training) or by Individual Recognition (evaluating individual skills). Figure 10 depicts the differentation between a Blanket Recognition and an Individual Recognition. The first method obviously is much less time consuming; in both cases, Moon's approach represents a valuable asset. For Blanket Recognition, the acknowledgement for specific vocational and advanced trained groups was investigated by one specific example, afterwards it can be used as a path for candidates with equal or higher qualifications.
For the Individual Recognition, each student will be evaluated regarding all for his or her competencies. This includes the consideration of competences recorded in supporting documents of vocational training. For this case, the usage of the so called "Qualifizierungspass" or "ProfilPASS" is advantageous. The Qualifizierungspass was developed for second-chance qualification measurements under conduction of the Federal Institute for Vocational Education and Training (BIBB). The ProfilPASS is administrated by the German Institute for Adult Education (DIE) and takes all the learning settings into account in which learners acquire skills and competencies. The competencies recognized due

to these passports is advisable for the practical sections in studies like practice courses in laboratories.

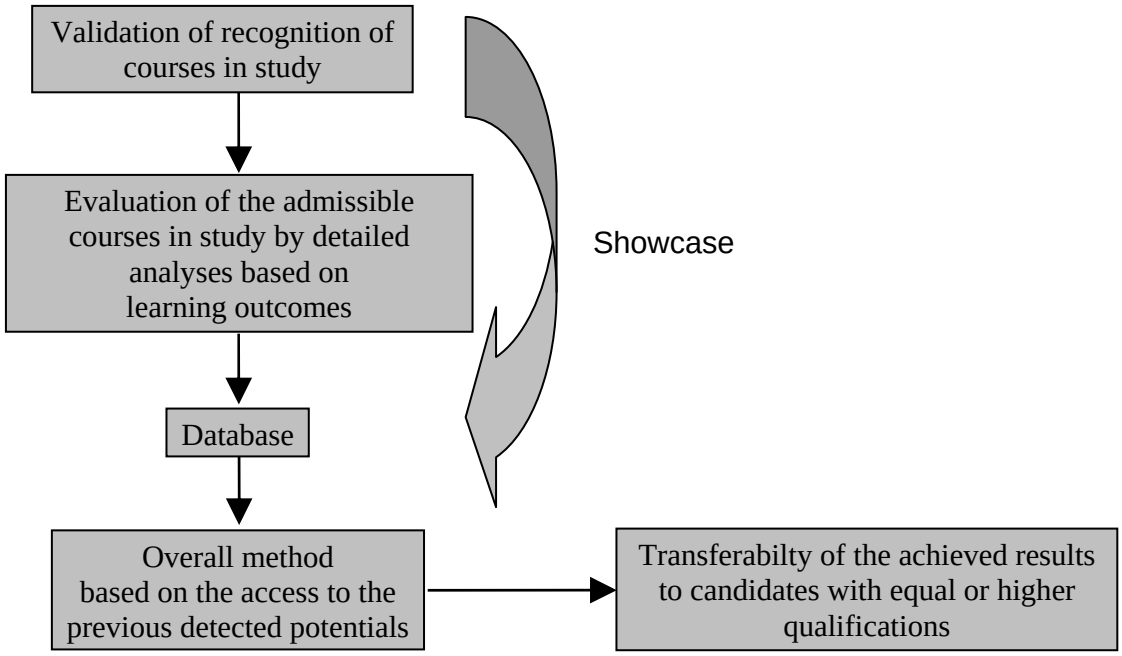

Figure 9: Approach to evaluate the recognition for a module of studies

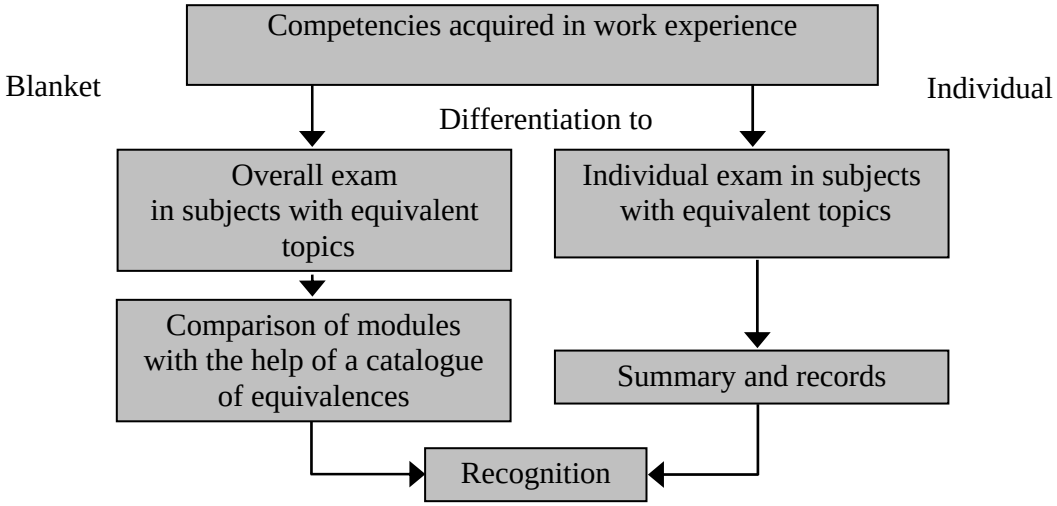

Figure 10: Blanket and Individual Recognition

Conclusion and Outlook

An approach to compensate for a lack of students in the technical field in the European community is to tab into the reservoir of skilled workers with vocational training, thus creating a permeability between vocational professions and universities. By acknowledging vocational skill en lieu of academic classes, both an increased attractiveness as well as a

reduced time to gain an academic degree is intended to be achieved. A precondition is to clearly specify learning outcomes applicable both to the vocational and the academic field. This was accomplished by applying the system of Erpenbeck and Heyse for differentiating between formal, non-formal, and informal qualifications, as well as applying an approach of Moon to differentiate between the levels of the competencies. This approach provides a standardized method for the recognition of vocational competencies based on the usage of learning outcomes. The taxonomy applied assures, that only competencies are recognized which students did acquire because of their previous vocational training. The application of a standardized recognition concept leads to a higher transparency of the recognition process and enables an equal treatment of students with previous vocational competencies. Altogether, the concept presented results in a reliable recognition of professional competencies. The system also lends itself to evaluating the transferability of the concept to other fields taught at the Leibniz University Hannover. To evaluate the concept, the next step will be a trial run with probands.

Acknowledgement

This work is sponsored in part by the Federal Ministry of Education and Research (BMBF) and the European Social Fund (ESF) within the framework of the program “ANKOM”. The authors would like to express their gratitude to Dr. R. Buhr, VDI/VDE-IT, Berlin, Germany, and K. Mucke, BIBB, Bonn, Germany, for their support of "ProfIS".

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