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## **Vocational educational science**

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### **1 Approaches to Vocational Educational Scientific Research**

The world-wide socio-economic processes of change such as globalisation, the information age and the changing environmental conditions have a considerable impact on our societies in terms of the design and organisation of the world of work, and also on vocational education. Alternative ways of re-thinking and new structures are imperative for vocational education to prepare the individual for meeting the challenges of changed requirements and for a long professional life with permanent changes (cf. Spöttl 2008; cf. Höpfner & Koch 2003; cf. Songthanapitak & Schröder 2012, cf. OECD 2013).

In this sense new qualifications, competence and occupational profiles will have to be continuously developed and the curricula need to be adapted accordingly. These reflections are centred around a constant development of the occupational profiles on the level of skilled workers and technicians and the related corporate and societal demands and expectations (cf. Spöttl 2009; cf. Spöttl & Becker 2008). Representatives of the GTW (Gewerblich-Technische-Wissenschaften) community in Germany and the Institut Technik & Bildung (ITB) of the University of Bremen are conducting research in this complex subject area at the interface of work, technology and education. The research discipline resulting thereof it is referred to as vocational educational scientific research (cf. Becker & Spöttl 2008).

The discipline is developing into an independent research discipline within vocational education supported by adequately qualified vocational educational researchers. They are a crucial prerequisite for research and the systematic further development of this special academic discipline. Another must is the training of scientific junior staff. This is not guaranteed everywhere (cf. Lipsmeier 2010). Independent research focused on vocational education also aims at improving teacher training and the further development, the adaptation and a continuous improvement of vocational educational systems. Above all in vocational education it cannot be taken for granted that universities are conducting research along with their teaching activities. However, universities can best comply with their societal education mandate if they generate knowledge through research which – in turn – enhances teaching and is suitable for the further development of the vocational educational systems.

Apart from the socio-economic and societal aspects, also cultural and ecological issues are playing a role in vocational educational scientific research. Other factors are technology, business and work processes and the occupation itself. The research and development activities encompass corporate learning and vocational initial and further training, vocational learning and learning at school in vocational contexts, pre-vocational education and the interface

between vocational and academic education. Vocational educational scientific research covers a total of seven important areas and even investigates the boundary areas that also affect vocational education and training.

With regard to a medium-term development of research capacities and the establishment of a scientific discipline, further research accesses have to be opened and integrated into teaching. This article describes the example of vocational educational sciences. First of all the most relevant research areas will be identified.

### **1.1 Design (shaping) of work and technology**

In the sense of a cross-sectional field, technology will be investigated as the object of the work and information system in the world of work, as machine and medium of vocational learning and as a means for learning processes. This results in questions on the modes of development and the application of technologies as well as on their socio-cultural and legal contexts. Consequences for learning and teaching and the didactic design of vocational learning will be more closely investigated in this context and conclusions for the shaping of learning will be drawn.

### **1.2 Work and qualifications**

Vocational educational scientific qualifications research is dealing with work processes and the interactions within the educational and the employment system. The researchers take a closer look at the vocational pedagogic realization of education and training as well as at the work processes and systems, the structures of initial vocational education and the education sector in general and at various areas of employment. Information deficits and undesirable developments will also be observed and – based on the findings – proposals will be developed to overcome them.

### **1.3 Learning and teaching in vocational education**

The specific environmental conditions at school and in the training companies exert influence on the acquisition of professional skills, social and self-competences. One learning environment imparts these competences with a focus on learning while the other concentrates on practical application. However, the effectiveness is strongly dependent on the learners. Vocational educational scientific research investigates whether and how individual environment-related and multidimensional acting contributes to the development of competences.

### **1.4 School development and teaching quality**

Up to the beginning of the 1990s, reforms carried out in numerous countries concentrated only on classroom teaching (micro-level). Later reforms also included school organisation (meso-level). At least since the beginning of this century, when the need for a multi-level intervention was recognised, vocational educational scientific research approaches have embraced the entire (vocational) school system (macro-level). An important research object is

represented by the so-called influencing variables for the development of school and teaching quality.

### **1.5 Work and technology as object of pre-vocational education**

Vocational training is preceded by the phase of general education. It is as important as initial vocational training itself and marks the first step into the labor market. Both the teaching and learning research and vocational educational scientific research perceive the development of vocational competences as a continuous process and calls it an achieved "state", which is based on its prerequisites and is in turn itself a prerequisite. It is therefore obvious that pre-vocational education with its references to the world of work and its occupational references have to be investigated more closely.

### **1.6 Occupations and vocational education systems**

Occupational profiles, occupational families, vocational and learning fields as well as curricula in the vocational education processes have to be constantly redesigned. With a view on the global world of work, vocational educational scientific research deals with structural framework conditions, competence profiles and societal recognition. The vocational education systems – from school up to initial vocational education and further education – are also in the focus of interest.

### **1.7 Teacher training**

The education and further training of instructors and trainers in companies as well as the teaching staff in vocational schools is playing a key role in any perception of vocational education. This is why vocational educational scientific research has developed a concept for the training of teachers for vocational schools and colleges based on a scientific perspective. This approach still requires further research and proposals of concepts that may be acceptable in a global context (cf. Hattie 2012).

The chapter below will briefly describe the historical development of teacher training for vocational schools in Germany – with vocational educational science as its preliminary result.

## **2 Historical development of vocational sciences**

After various development phases ("reduced engineering science", "teaching- oriented scientific discipline" and "work-oriented vocational science"), work process knowledge and the implications of a highly complex world of work as well as the resulting consequences for vocational education and teacher training form the centre of multi-faceted surveys of educational and work-process oriented vocational educational scientific research. It is assumed that the connection between vocational education, vocational qualification and the individual subjective interests of the skilled workers and company owners as well as societal interests from a company perspective could considerably contribute to the clarification of various issues such

as the shaping of curricula, the design of vocational learning and occupations, occupational fields and vocational educational and qualification processes. A great number of research works, published above all in the 1990s, underpinned the necessity to concentrate vocational educational scientific research on work processes and their implications. (cf. Drescher 1996; Niethammer 1995; Fischer 2000; Schlausch 1997; Bannwitz & Rauner 1993; Spöttl 2000; Rauner & Spöttl 2002) This development is based on Stratmann's (1975) postulations to make work, technology and education and their interactions the research object of vocational educational scientific research. First and foremost he considers this an option to overcome the manifold attempts by GTW (with vocational sciences as their umbrella) and to shape study courses for teachers at vocational schools from the fields of engineering sciences, work sciences, natural and social sciences as well as vocational pedagogics. By concentrating their research on this context, vocational educational scientists hope to identify acceptable scientific structures and to contribute to a process of theory construction which helps to form an independent profile of the discipline – and thus also of the training of teachers for vocational schools – at universities. This could also intensify vocational educational research. The great number of reference sciences nevertheless causes a problem. The required deeper reflection of these disciplines cannot be realized in the short term. Consequently the training of teachers for these areas will continue to show deficits. However, if we assume that a vocational educational scientific study course will yield vocational pedagogues (teachers at vocational schools) with the ability to shape vocational educational processes and qualifying work processes, four specializations for GTW (today called vocational educational sciences, GS) can be identified (cf. Martin, Pangalos & Rauner 2000, 22):

- Development of professional skilled work and the occupational fields;
- Learning contents of vocational education as a dimension of analysis, design and evaluation of vocational educational and qualification processes;
- Analysis, design and evaluation of professional skilled work in terms of learning contents and learning opportunities;
- Analysis, design and evaluation of technology in terms of preserving and promoting specialist competences.

On the one hand these subject areas sketch the objects of university curricula of vocational educational sciences. On the other hand they outline the contents to be researched with the aid of vocational educational scientific methods and instruments (cf. Becker & Spöttl 2008). In this fourth phase of the development of vocational educational sciences for vocational and technical occupational fields the work and work-process oriented knowledge becomes the object of vocational educational scientific research – also from a subjective point of view (cf. Fischer 2000, cf. Illerins 2003).

The field of objects of vocational educational sciences is the relationship of technology and vocational education within the framework of professionally organised skilled work. The focus of the theme restricts the arbitrariness of the aspect of “technology” without violating

the characteristic structure of the field of objects: The vocational acting competence and the specialist theory of a skilled worker required for a competent handling of systemic technology are thus the central issues of the field of objects (cf. Martin, Pangalos & Rauner 2000, 13). This perspective of imparting specialization-relevant contents differs clearly from imparting contents in engineering study courses. Teacher students of vocational technical specializations whose specialist scientific training depends on a reduced offer of engineering study courses are not sufficiently prepared for the mastering and imparting of the professional knowledge of their prospective vocational teaching practice in vocational education and training. Teachers should, however, rather be trained in their vocational specializations and for both practice-oriented and scientific vocational education. This has repeatedly been agreed upon by KMK (cf. KMK 1973, KMK 2007).

### **3 The importance of vocational educational sciences for the training of vocational teachers**

According to the KWM framework agreement, study courses have to be designed in a way that they take account of the swift development in the various occupational fields and to impart future-oriented action competences. (...) The study course encompasses educational sciences with emphasis on vocational or economic education as well as subject didactics for the occupational specialization, scientific disciplines within the vocational specialization as well as a BA and MA thesis (cf. KMK 2007, 2). In order to meet these demands, the training in technical vocational specializations is linked to the general professionalization of teachers. On the other hand it has not yet been clarified which specialist knowledge teachers will require to enable them to scientifically reflect and understand the specialist theory of skilled workers necessary for a competent handling of technology and for creating the basics for professional action situations. This is where research has to set in and it must also develop and discuss standards for teacher training (vgl. Spöttl & Becker 2012).

Nevertheless it is generally difficult to exactly describe the specialist theories that are guiding the actions of skilled workers, to systematize them, to clarify their special importance for the work process and to identify their scientific principles. This problem is mainly due to the considerable dynamics and increasing complexity with regard to corporate organisation development and technological innovations. Even more difficulties arise when it comes to a clarification of the conditions of a systematic acquisition of professional action competence.

### **4 Requirements for vocational educational sciences as scientific disciplines and their research**

The vocational educational scientific approach deals with access to work, work processes, changes in the work and the related implications. The results can be used for conclusions with regard to the need for qualification, qualification and occupational profiles, the design of curricula and consequences for learning processes.

The (occupational) educational scientific approach to qualification research is based on the fact that the perspective of insight into curriculum research and curriculum development and/or curriculum design must aim at the safeguarding of subject development and evolvement. This can, however, not be guaranteed and societally accounted for without the foundation of an empirically secured need assessment of concrete work capacities. Socially necessary working capacities are the result of complex configurations based on technological, economic, legal and social developments (cf. Spöttl & Lewis 2008).

It is likely that the “research on early recognition” of a need for qualification will play a predominant role in the future. There are at least two approaches:

- a) Prognosis and prospective vocational educational research (cf. Grollmann 2005, Leney et al. 2004; Schmidt & Steeger 2004; Schmidt 2003).
- b) Research approaches with a focus on vocational educational science (Windelband & Spöttl 2003 a+b; Spöttl & Windelband 2003; Spöttl & Windelband 2006).

Prognostic research and research on prospectivity in vocational education began to deal with the future of vocational education in the 1960s. This research aims at providing an empirically verified contribution to the planning of vocational education. There has been a long-standing argument about whether prognostic research is able to yield reliable results for the future along with the necessary openness for the future. The roots of prognostic research encompass at least classical educational planning and educational economy, the assessment of the consequences of technology and economic and social scientific prognosis research as well as industry sociological research and their numerous varieties. Step by step this research approach has been criticized from various sides resulting in a “prospective turning point” based on openness towards the shaping of work and technology and thus “relativising” the approaches to prognosis (cf. Martin & Rauner 1988).

In the course of the analysis, the shaping and the evaluation of work processes it is crucial to adhere to a process-oriented – contrary to a task-oriented – perception of work contexts (cf. Storz 1999, 146). This is where the approach clearly differs from empirical social research. The latter does not aim at identifying results for the creation of occupations and curricula by means of analysis and shaping of the object-related part of work, work results, means of labour and processes (including company and work organisation). Vocational educational scientific research, however, looks at occupational skilled work in a differentiated and non-deterministic way (cf. Storz 1999, 135). A certain proximity of vocational educational scientific research on ordinances as application-oriented research of actions can be noted within the scope of technology and qualification (cf. Sauter 2000). Research on ordinances has the disadvantage that it is reduced to the practical integration into ordinance work. As a result it can – if at all – only have an orienting character. In short: research on ordinances is governed by the purposive rationality of ordinance politics. Vocational educational scientific research is considerably more far-reaching and is not subject to the above mentioned limitations.

The professional requirements for the designers of vocational education encompass the ability to impart contents in a didactical-methodological way. On the other hand, themes should be conscientiously identified and prepared. This requires a sound knowledge of the needs and aims of vocational education in order to be able to design occupational educational processes. This means that professionally organised work within an occupation or an occupational field is the central benchmark for all designers of occupational educational processes. It must be the core of the professional education of vocational pedagogues. This is why this study area must be scientifically shaped for each and every occupational field. The discipline that can achieve this goal is vocational educational science (cf. Pahl 1993, 40). The most important references are “professional work”, “professional knowledge”, “professional theory” and vocational education. In terms of a “professional work”, vocational educational science must investigate the forms of professional work (cf. Rauner 1993, 29) and/or the relationship between man – machine – work place – company and their interrelationships (cf. Illeris 2003).

The current relevance of vocational educational scientific research is based on three principal considerations:

- Firstly: It results from the need for a new quality in shaping occupational profiles and vocational structures as well as finding answers for didactical issues.
- Secondly: It is based on the necessary professionalization of “vocational educational staff” by a university study course of “occupational specialisations”. The design and stabilization of these subjects is essential for vocational educational scientific research.
- Thirdly: It should promote the development of an academic discipline in the sense of occupational specializations under the umbrella of vocational education and training and economic education.

Vocational educational scientific research can provide answers on how the objects of skilled work, the occupational structures and the occupations, the business and work processes and the structures of occupational clusters are changing, as it not only investigates this kind of leading questions but also applies methods of adjacent disciplines. It is, however, important that the answers are generated by adhering to a sound knowledge of the internal structures of professional work (cf. Spöttl 2010a; Becker, Fischer & Spöttl 2010). The inductive character of this research, however, results in the fact that the answers deal with references to the sector level, to the level of occupational clusters and to superordinate contexts regarding the design of occupations, occupational profiles and curricula, also relevant for the education and professionalization of vocational pedagogues (cf. Spöttl 2010). It is beneficial that the considerations and answers can be empirically verified. This is above all true for theoretical references regarding the interrelationship between characteristic work tasks and processes as well as the incorporated qualification requirements. Research must concentrate on the didactical importance of these tasks for the development of competences in professionals in the contexts of their work.

It can of course be argued whether above all ergonomics can make an important contribution as a reference science. This will not be dealt with in this article. Instead we underline the necessity of empirical research in order to clarify the theoretical systematics for reference sciences. An empirical-scientific approach can help to overcome the prevailing deficiencies of vocational educational scientific research. This concern is very important due to the fact that the development of societies and the world of work are nowadays no longer linear but are dominated by many influencing factors. Vocational educational scientific research is suitable to access the complexity of the world of work from a vocational perspective. Wherever the parameters of dynamic work and work objectified within technology can also be accessed in terms of societal and social aspects, not only questions regarding occupations, vocational education, learning fields and curricula can be answered. There will also be findings useful for the theoretical shaping of occupational specializations as reference sciences for the professionalization of vocational pedagogues.

Already in the last century, Stratmann (cf. 1975, 335 ff.), Grüner (1970, 446) and Müllges (cf. 1975, 810 f.) referred to the possibility and the necessity of an empirically oriented vocational educational science. Pahl (2001) names further authors who have spoken out on the state of empirical research in vocational education: Beck and Kell (cf. 1991, 12) remarked, that the future of empirical vocational educational science had not yet begun. In his essay “Erträge und Aufgaben der Berufsbildungsforschung” Achtenhagen criticizes that vocational educational scientific research, above all in vocational pedagogy and economic education, is not adequately developed, that there are not enough opportunities to publish the findings and thus cannot call adequate attention to the problems of education (cf. Achtenhagen 1991, 187).

These already older statements accurately sketch today’s situation. At the same time the German Society for Research (Deutsche Forschungsgemeinschaft) criticizes the lack of empirical-analytical vocational educational scientific research (cf. DFG 1990, 17). The statements refer to the already discussed problem of reference sciences for the professionalization of vocational pedagogues. On the other hand they emphasize the urgent need for empirical approaches to the research objects and the clarification of knowledge and skills structures in employees. This is also underpinned by a popular perception taken from developmental psychology: the acquisition of content knowledge is no crucial prerequisite for an occupation. To know how to learn would be sufficient (cf. Gerstenmaier 2004, 154). The recent state of expertise research has, however, clearly shown that the separation of learning from context-related knowledge contents is leading to “inactive knowledge” which can only hardly – if at all – be used for coping with new tasks and problems. According to these findings, the access to area-specific knowledge or domain knowledge is linked to contents and related subjects. Thus it is necessary to clarify how occupational mastery can be achieved and to investigate the role of knowledge structures acquired during an application context and resulting in performance. The works of Franke (2001, 2005), Neuweg (1999), Polanyi (1985) and Ryle (1969) have considerably contributed to a theory-oriented clarification of the relationship of knowledge, abilities and competence which have to be taken into consideration for the further development of research instruments.

## 5 Summary and outlook

A closer look at the research objects of vocational educational qualification research clearly reveals their interdisciplinary and at the same time their individual character. Qualification research is often assigned to a single discipline. This leads to basic logical scientific problems (cf. Pätzold & Rauner 2006, 15) and to a curtailed reflection of the objects to be researched. The problem has already been mentioned in the 1970s (cf. Grüner 1970, Stratmann 1975) and during the emergence of a vocational educational scientific research tradition (cf. Pahl & Rauner 1998, Pahl 2005, Spöttl 2012). Qualification research that is only based on a single perspective (e.g. on work sociology, education sciences, vocational pedagogy, ordinance politics, labour market orientation or economy/ecology) therefore reveals deficits in its empirical and education-theoretical foundation and above all in its research methods. This can be prevented by applying vocational educational scientific instruments. Therefore vocational educational scientific qualification research always adheres to the following three levels (cf. Spöttl 2000):

- Sector structures and the contents of the work of skilled workers (tasks as well as business and work processes). This dimension concentrates on the relevant situations which determine the conditions for acting.
- Competences of the skilled workers (knowledge and abilities to master and to shape the work processes). This dimension concentrates on the scientific aspect in the sense of knowledge structures for an occupation or a domain (cf. Rauner 2002, 530).
- Conditions and structures for the development of competences/ vocational education (competence development/ learning processes of the individual). This dimension concentrates on personality.

The consequent context orientation practised by vocational educational scientific researchers has often been criticised: their methods would only be applied to investigate the occupational requirements and neglect the educational aspect. However, the opposite is true and was often the trigger for a further development of research-methodological approaches of adjacent research disciplines (cf. Becker 2003, 38ff.).

Nevertheless, a more thorough methodological discussion and a precise theoretical justification as well as more precise research instruments are still lacking. These steps still have to be taken as vocational educational scientific research has so far relied on and applied the methods of other disciplines. The contents and forms of work and educational processes in the different sectors require context-oriented research and development methods which are still in need to be further justified and theoretically underpinned (cf. Becker & Spöttl 2008).

Finally it should be underlined that the vocational educational sciences have already intensively recognized empirical vocational educational scientific research. In addition they are increasingly prepared to support the design of occupational specializations in a more differentiated way. Apart from this they have engaged in the clarification of open questions such as the problem of systematics – to process knowledge for teaching and learning. Specialist sys-

tematics is a well-known fact. However, the shape of action systematics which should replace it, remains more or less vague.

The problem of generalizability remains to be clarified as well, i.e. the question must be answered how the situation- and context-related, volatile and unique elements of work process knowledge can be generalized. And the problem of transferability must be solved as well. The ability to solve difficult tasks is based on recourse to available well-structured patterns which contain a number of identical elements necessary for the mastering of a new task. Expertise results from the availability of such patterns. These questions are highly relevant as established action patterns are no longer sufficient due to the vocational educational scientific reflection of the object in research and teaching.

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