

# Learning Fields in Vocational IT Education – How Teachers Interpret the Concept

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**Abstract.** Vocational schools in Germany are part of the compulsory school system, but they differ from other secondary school types. They combine theory and practice by using learning venue cooperation between schools and vocational training companies. Taking this into account the curricula in the field of computer science (CS) and information and communication technologies (IT) are arranged in so-called "Lernfelder" (learning fields). Learning fields are worded openly, so teachers get leeway to select learning content for their purposes. But it seems that teachers interpret the concept of learning fields quite differently. The question is: How do vocational IT school teachers deal with learning fields? The elicitation study described in this paper explores the IT teachers' knowledge of the concept of learning fields. It is part of a project which aims to develop exemplary learning situations and helpful tools for several learning fields, which will support teachers in creating lessons in this context.

**Keywords:** Vocational IT Education, Computer Science Education, Learning Fields, Learning Situations, Teachers' Attitudes, Empirical Study, Elicitation Study.

## 1 Introduction

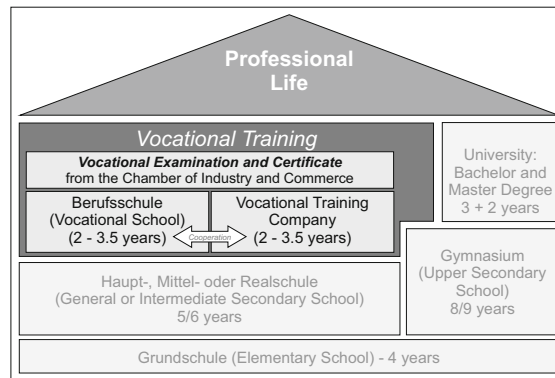
### 1.1 The Vocational School System in Germany

Ways to professional life in Germany are different from most other countries. Young adults can choose between many different paths to take up training for an appropriate occupation. One important possibility is to attend an upper secondary school, called "Gymnasium", where they get a general qualification for university entrance. Another way is to attend a general or intermediate secondary school. After their school-leaving qualification these students can take up training and education at companies and part time vocational schools<sup>1</sup> (so-called "Duale Berufsausbildung" – dual vocational education and training) for two or up to three years (depending on the chosen occupation; during this time the students

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<sup>1</sup> In this paper "vocational school" means only schools for dual vocational education and training; full time vocational schools are explicitly not included.

are apprentices and employees of their training companies; the general age of the students is between 16 and 25 years), whereby students receive a vocational certificate from the chamber of industry and commerce or the chamber of trade (see fig. 1). There are different models of school attendance; in former times students attended classes one day a week, nowadays there are full-time classes for one or two weeks, followed by two or up to four weeks of training on the job at the company.



**Fig. 1.** A simplified depiction of the German school system

At vocational schools, the students' previous knowledge and education as well as their ages are very heterogeneous; this implies different types of learners in each school class, who need different types of instruction to benefit from lessons [6]. For this reason all vocational schools are supposed to impart general and occupational education. To devise their lessons, teachers should use activity-oriented forms of teaching. To help them to find such forms of teaching, the learning content in the curriculum is arranged in so-called learning fields, which are suitable for implementing activity-oriented learning situations. This way to a professional life can be found only in individual countries and the idea of learning fields is quite new.

So it is no wonder that there are only few publications about this specific concept for vocational education and training [5], most of them directly from Germany. Nevertheless especially in engineering there are many publications about the current reform of the vocational school system in China, where ideas like the cooperation between school and business, integration of work and study or teaching in working scenes are described, too [8] [13]. These publications show a growing interest in developing suitable concepts for vocational IT education<sup>2</sup>. The concept of learning fields can be a valuable idea not only for the area of vocational IT education, but can be also a food for thought for all types of secondary schools.

<sup>2</sup> IT education includes also computer science education.

## 1.2 Learning Fields in the Curricula of IT /Computer Science Education

The apprentices are trained for their companies needs. They learn to solve the specific problems of their job. But it is also necessary to teach basics and theory of the profession in such a manner that students can recognize the links between theory and practice.

So the concept of learning fields was developed to better meet the requirements of all partners of the dual vocational education and training; vocational school and training company should become equal partners. A curriculum arranged in learning fields can ensure modern education, which helps the students to gain competencies in different areas, and not only technical skills.

Learning fields are topical units, which contain didactically reduced business and working processes, but they do not include specific aims to be reached or skills to be acquired. They describe different competencies which students should gain. By alternating multidisciplinary theoretical and practical training, students should acquire the competencies to apply their skills in new professional situations (see fig. 2).

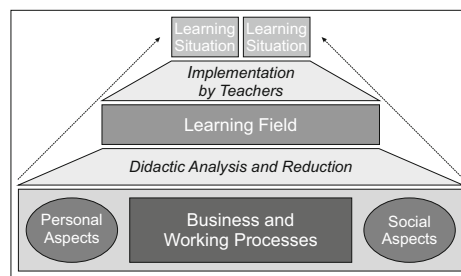
<b>Learning field</b>	<i>(first year, 60 lessons)</i>
<i>Application development and programming</i>	
<b>Aims:</b> The students are capable to analyse, design, implement and programme complex application systems. They design didactically reduced applications methodically and appropriately. They reflect on their approach and provide aspects of quality assurance. They apply methods of software development and implement applications based on known algorithms and data structures by using software development tools. They are enabled to reflect their strategies.	
<b>Content:</b> <i>Development of application systems</i> <ul style="list-style-type: none"> <li>• Model of project management</li> <li>• Development strategies and action models for software engineering</li> <li>• Methods and procedures of quality assurance</li> <li>• Methods of actual analysis of business processes and IT systems</li> <li>• Methods and tools for developing solution concepts and documentation</li> </ul> <i>Methods of programme development</i> <ul style="list-style-type: none"> <li>• Basic algorithms and data structures</li> <li>• Structuring and documentation</li> </ul>	

**Fig. 2.** Example for the definition of a learning field (in German) [18]; translation by the authors

To model a learning field (see fig. 3), it is necessary to find out typical business and working processes for this occupation. But a learning field is not only a reduced process, but a didactic concept; a learning field will be created by reflecting and reconstructing professional activities [2]. It is important to include and connect theoretical and professional skills from different subjects, but also social and personal competencies. The resulting curriculum should contain all skills and competencies the students should gain during their training.

It is up to the teachers at school to implement the learning fields into suitable learning situations. A learning situation contains one single working process, which has been didactically reduced; so the aims and competencies which are defined for this learning situation can be reached by the students. An annual

didactic planning should ensure that the chosen learning situations are coordinated each year. The teachers have the leeway to adapt the curriculum to their spatial, personal and social conditions. This way of working can be used by vocational school teachers to free themselves from fixed structures in teaching. A learning situation contains theoretical knowledge, several working skills and different competencies to solve complex problems. That may cost time, but one part of the concept is to enable teaching in teams [4], so teachers from different disciplines can share the workload and support each other. Therefore this concept is not a single method; it is a different concept of teaching and learning for all parties concerned.



**Fig. 3.** From business and working processes to a learning situation

Concepts of interdisciplinary collaborative teaching and learning can be found in different scenarios of vocational training and education. Shooter and McNeill [17] describe courses in mechatronics with students for mechanical and electrical engineering, who work in interdisciplinary groups with activity-oriented methods. The curricular reform of computer engineering education in Egypt follows another path, which seems similar to the concept of learning fields. To prepare students for practical life, the students participate in interdisciplinary programs, where they study all important topics of their major field; this includes engineering and non-engineering skills [16].

The idea of teaching theoretical knowledge by using activity-oriented, interdisciplinary projects can also be found at the constructivist concept of “contextualized teaching”. This concept is developed for secondary schools to bring the students into contact with different aspects of a given problem, which is situated in their own environment and life. So “contextualized teaching” covers not only technical, but also social or methodical skills [7].

Unfortunately, in the area of IT the definition of learning fields has not always succeeded. Some learning fields seem to be identical to the former school subjects [10]. For example, one learning field of the curriculum is called “*application development and programming - methods of software engineering*” (see fig 2). This learning field contains different methods of software development, but the description of the competencies of this learning field only consists of technical knowledge; aspects of social or personal competencies or relevance to the

students' life are missing. So it is tempting for IT teachers to work with the familiar subjects without thinking further about the specifics of the learning field.

It appears that especially in IT-centered vocational schools, in classes for "Fachinformatiker" (IT specialist for system integration or application development), "IT-System-Elektroniker" (IT system electronic technician) or "IT-Systemkaufmann" (information technology officer) the concept of learning fields is hardly implemented by the teachers. One indication is the existence of only a few (German) publications about teaching with learning fields in vocational IT classes (e. g. by Linke and Rohland [9] or Repp [14]), in comparison to many more about the basics of the concept ([2], [3], [15], [19]).

Several discussions during conferences confirmed the impression that teachers give away the advantages of the concept by devising their classes in a traditional, teacher-centered way. Therefore we tried to find the problems teachers at vocational IT schools meet when translating the described competencies from several learning fields into adequate learning situations.

So the question was: how do vocational school teachers handle the concept and how do they use the leeway given to them by the curriculum?

We conducted an online survey with several IT teachers<sup>3</sup>. In this paper we present the results of this elicitation study. It is part of a larger project with the purpose to convince vocational IT teachers to devise their classes according to the learning field concept by developing exemplary learning situations or helpful tools for several learning fields.

## 2 Methodology

In 2011 we asked all vocational IT teachers (around 100 according to the information of the Ministry of Education and Culture) in Bavaria (Federal State in Germany) to participate in the online survey. We got 31 answers (a response rate around 30%), only  $N = 28$  questionnaires were completely answered and evaluated. The online questionnaire consisted of three sections.

First, all participants were asked for their age, sex, vocational discipline, years of teaching (as range) and the educational subject.

The second section contained closed questions about the IT teachers' knowledge of and attitudes towards the concept of learning fields. One item explored the participants' familiarity with the concept of learning fields. We used a 5-point scale answer format with options from "does not apply at all" (1) to "fully applies" (5).

The third part consisted of six open questions. The first ones were specifically formulated for categorizing the answers following the theory of planned behaviour by Aizen and Fishbein [1], which is suitable to explore the influence of the attitudes towards the concept of learning fields on the teachers' behaviour<sup>4</sup>:

<sup>3</sup> IT teachers include also teachers for computer science.

<sup>4</sup> The survey was carried out in German; all questions, items and answers were translated by the authors.

- “*What do you believe are the advantages of arranging the IT learning content in learning situations?*”
- “*What do you believe are the disadvantages of arranging the IT learning content in learning situations?*”
- “*What factors or circumstances would enable you to arrange the IT learning content in learning situations?*”
- “*What factors or circumstances would make it difficult or impossible for you to arrange the IT learning content in learning situations?*”

To explore the situation at different schools we asked for examples of learning situations from different classes and schools:

- “*Would you please describe the learning environment for teaching in learning fields at your school?*”
- “*How do you organize teaching in learning fields in IT professions at your school? Please describe at least one learning situation which you use for teaching in your learning field.*”

### 3 Results

#### 3.1 Statistics: Sample of Participants

First we want to give an overview of the structure of the sample of participants partaking in the study. We got replies from 21 men and seven women. The average age was  $M = 47$  years (standard deviation  $SD = 12$  years). The median of the years of teaching is within the range of 11 to 15 years.

Ten teachers reported that their vocational discipline was electrical engineering and information technology, 15 were teachers for business education, one was a teacher for health care and another one was a teacher for metal technology; eleven teachers specified that their second subject was either computer science or IT technology; regarding the overlap between vocational discipline and second subject, there are 16 teachers basically educated for teaching IT.

All teachers declared to work in IT schools in different learning fields.

#### 3.2 Results of Closed Questions

The answers of the second part of the questionnaire were also summarised following the theory of planned behaviour [1]. This theory consists of a model with three predictors for human behaviour. The first predictor concerns the attitudes towards a subject, the second is represented by the subjective norms (persons or groups), and the third predictor is perceived behavioural control, characterised as control beliefs and self-efficacy of behaviour.

All items contain aspects of this model; only the first question about familiarity with the concept of learning fields does not represent this theory, but shows an individual estimate of the personal skills on this topic.

The results of the closed questions [12] show that the teachers feel familiar with the concept of learning fields (mean value  $M = 4.21$ ). Their attitudes towards the concept seem positive ( $M = 3.36$ ), also their self-efficacy ( $M = 3.21$ ) to develop suitable learning situations. The only predictor which seems to be regarded more negative, is the aspect of control belief ( $M = 2.83$ ), which means external factors like school equipment or the individual teaching schedule.

Concerning these findings the teachers seem to be open-minded to devise their classes by using adequate learning situations.

### 3.3 Results of Open Questions about Beliefs and Attitudes

By using methods of content analysis we paraphrased the first four open questions and produced  $N = 151$  statements, which were categorised following the theory of planned behaviour [1]. This content analysis verifies the results of the closed questions [12]:

The statements about the teachers' attitudes ( $n = 47$ ; 31.1%) specified the findings of the closed questions: The teachers said that they would see the advantages and the leeway given to them by the concept, but they also would consider the difficulties to teach basic IT knowledge by using learning fields.

More than the half of the statements came from the category of control beliefs ( $n = 102$ ; 67.6%), 65 were negative. Many teachers reported problems with school equipment, room management or the general time management at their schools, but there was also great praise about these facts. Other aspects were the strong heterogeneity and the size of the classes, the teaching staff composition or problems with administrative work.

The last two statements about the subjective norm of the teachers said that their colleagues or the headmaster of their school supported the concept of learning fields.

These results show that the teachers have a quite differentiated view on the advantages and problems which could result of putting the concept of learning fields into practice. So it could be valuable to help the teachers to overcome their reported problems.

### 3.4 Examples of Organization and Learning Situations

**Organization of Learning Environment.** We asked how the learning environment was organised at the respective schools. Only 21 IT teachers answered this question. Nine IT teachers said that they did not put the idea of learning fields into practice. The others reported they partially tried to implement the concept by carrying out several projects ( $n = 7$ ; two of them carry out interdisciplinary projects) or by using different activity-oriented methods ( $n = 8$ ).

One important aspect of implementing classes with the concept of learning fields is to carry out an annual didactic planning, but only five IT teachers reported doing that in any way.

We found several answers showing the IT teachers' problems with the whole concept:

*“We normally teach in subject area-oriented structures and do not implement learning situations. Activity-oriented lessons are organized as group work, but this does not follow any working process at all.”*

*“Basically the learning field-oriented classes take place in the suitable subjects. Each teacher can choose how to implement the concept of learning fields on his own.”*

The statements show that these IT teachers know what the concept of learning fields means: A typical learning field contains knowledge, skills and competencies from different topics and subjects; it needs collaborative teaching and an integrated view on the respective learning situation.

But the next example illustrates that at least this IT teacher does not completely understand what the concept of learning fields really entails:

*“I do not know how to answer that question, because our present curriculum is already arranged in learning fields. We teach by using learning fields; the only question is which methods are used. We carry out projects in the second and third year of training. Activity-oriented exercises are part of the lessons, but they are not a panacea. Our IT team carries out a simple annual didactic planning, but this could be improved.”*

The answer shows a widespread misconception: It is not enough to have a learning field-oriented curriculum to teach in appropriate learning situations. It cannot be called putting the concept into practice carrying out one project per year of training in any subject, but it is better than nothing. Putting the concept of learning fields into practice means to implement the whole curriculum in different learning situations by using different activity-oriented methods.

**Examples of Learning Situations.** The quality of the 11 described learning situations varies significantly. Some learning situations are highly suitable and cover most requirements; but there are also examples which should be improved. In the following chapter we describe some appropriate learning situations.

We arranged the described learning situations into the year of training in which the situation was used.

#### *a. Second Year of Training*

For the learning field “*business management processes*”, one teacher described the learning situation “*financing concepts for a prospective office expansion*”. Students are to learn all facts about financing and finance controlling and how to report the results to the management. The teacher uses different methods like blended learning or working with wikis; they get information from different banks, factoring companies or shareholders; they should use team work or partner work.



Although the learning field is described badly in the curriculum and the learning situation is not directly derived from the field of IT, it seems to be an interesting example with high practical relevance.

Another learning situation comes from the learning field “*application development and programming – methods of software engineering*”. It is labelled “*Trainee Bank*” by the teacher.

*“The class ‘founds’ a bank and the students learn to implement the business processes step-by-step into an object-oriented model. This model contains all important parts which are necessary to understand how to develop an object oriented programme by using Java: Students discuss several business processes, they implement these processes into use-case diagrams and develop sequence and class diagrams for the whole system. By developing the system, they become acquainted with concepts like encapsulation and inheritance. They also develop suitable user interfaces which should respect the rules of good software ergonomics. Students normally work in pairs; we also use tutorial systems to support the weak. New topics are taught by frontal teaching, but most of the time students work on their own.”*

This example seems to be very interesting. The learning situation contains many aspects of software engineering. A practical extension could be to integrate the teacher for business education – this would point out more precisely the general aspects of modelling software for business processes; the example could get more practical relevance.

Another aspect is worthy of discussion: This teacher related that she used this learning situation for all topics of the learning field. That means that she implemented the learning field into one single situation, which lasted one year of training. Disadvantages of this method could be that students learn only to use their skills for this single situation, it is not quite certain if they can use their skills to solve problems in modelling object-oriented software from another field.

#### *b. Third Year of Training*

The first learning situation from the learning field “*application development and programming – database development*” describes a project which was carried out in association with the teachers for German and Business Education:

*“Planning, developing and documenting a database for a real customer from the economy; we used different methods, especially group and partner work. The formed teams competed against each other to get the contract. But in contrast to real companies they also worked together, they supported and evaluated each other. Most parts of the specification were defined by the customer, but there were also a lot of degrees of freedom left for the students.”*

This sounds like a fascinating project for the students, especially since their work is not only valuable for training, but for a company. They learn to work together and in competition to other groups, they have to organize themselves and the project and they increase the depth of their knowledge. And this is the disadvantage of the described project: like most projects at school [11], it is suitable to consolidate their skills; but whether one team learns something new depends

on their willingness to increase the depth of their knowledge. From a teachers' point of view it seems random if and which skills and competencies are gained.

Another example from the learning field “*database development*” describes the “*development of a web-based application for the administration of geodata*”:

*“Students were free to define their specific problem. They had to catch up on the necessary information. On the first day they had to build groups of experts to explore one aspect of the problem, e.g. how are geodata structured or how to integrate a database into a webpage. After that they had to document and present their results. During the following days the students worked in pairs; they developed the concept for the application and implemented the software. During the last week, they presented their results and documented and described the entire project.”*

This seems also to be interesting, especially as developing web-based applications is not an explicit part of the basic curriculum. So the project is not only used to consolidate current skills, but particularly to gain new competencies in different areas. According to the definition of learning fields, all activity-oriented methods should be used to do this, and this project seems to be suitable for that. To carry it out, the students have to work in teams and they need the skills to research and rearrange information of the respective domain (here geodata) and the area of IT. They have to combine their current skills in software engineering and database development with their new knowledge. The students are relatively free in defining the problem; so even the weak students have the opportunity to master a challenge.

Especially the request for different examples from their school seemed to touch the teachers to the quick. Some answers were very emotional; other teachers took the chance to complain about their problems in implementing the curriculum. Especially the fact that teachers complained about their problems shows that it will be further important to help them on their way to interesting and meaningful learning situations.

## 4 Discussion

The results of this study seem to be inconsistent. On one hand, the IT teachers seem to be convinced of their skills in the concept of learning fields. They are sure that they are well-informed, open-minded and motivated to implement the curriculum into suitable learning situations.

On the other hand, the answers to the first set of open questions reveal that a significant part of the participants in the survey does not really know what it means to implement learning fields into learning situations. The first part of the project indicated that the definition of the learning fields for all occupations in the area of IT is improvable [11], so teachers can hardly notice possible misconceptions about the definition and implementation of this concept. What are these misconceptions?

The given examples suggest that the IT teachers focus on the professional skills and knowledge, which are used to prepare lessons depending on a subject:

First they define the technical topic, after that they look for suitable examples and methods; gaining further competencies happens by chance. So they seem unfamiliar with the opposite path: First thinking about all competencies to be gained in the current learning field, then developing suitable learning situations. This way, the focus is not only on professional skills, but also on personal, social and methodical competencies.

These strategies could be one reason that teachers consider one project each year as sufficient to train the non-professional skills; the rest of the year is described as a traditional mixture of teacher-centred education and activity-oriented exercises.

In addition, the analysis of the statements of the open questions indicates that IT teachers perceive the concept of learning fields as a single method which can be used for a more practical approach and to train social and methodical skills. Another central point is that some ideas can only be put into practice by the cooperation of teachers with different vocational subjects, a further step into the professional practice with teamwork as the general rule. Using teamwork intensively, lots of opportunities are opening up for implementing new ideas to motivate and teach the students to expand their own skills.

## 5 Conclusion

The question of this study was: How do vocational IT teachers deal with the concept of learning fields? The results show that most of the vocational IT teachers which participated in the online survey are motivated to implement the learning fields into practice. So in our opinion it is of no use to try to convince them of the advantages of the concept; but it seems to be helpful for the IT teachers to support them by developing guidelines with examples for learning situations and the related teaching material. It is also important to train the teachers on how to develop learning situations themselves in difficult environments, and how to evaluate criteria for appropriate learning situations.

So in our next steps we will explore important business and working processes in the field of IT. This will result in a range of possible learning situations, and develop suitable guidelines to lead the concept to a success.

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